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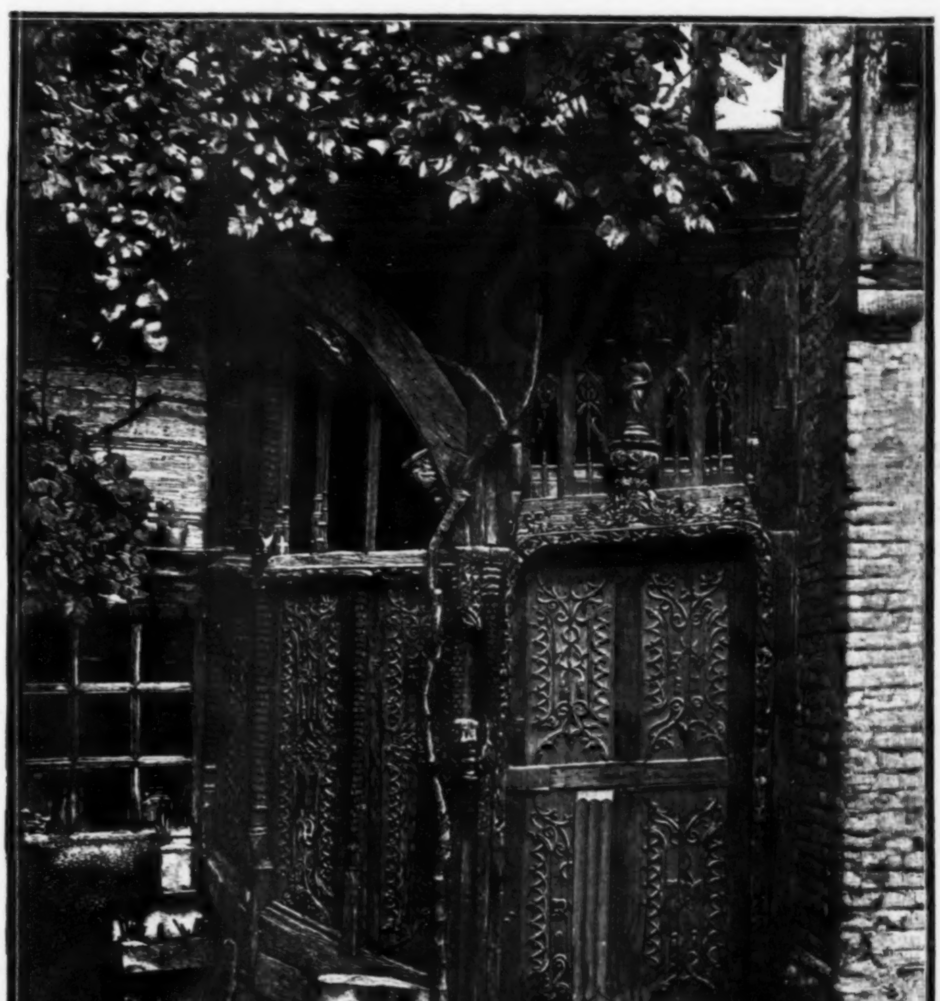
THE HOUSE OF FRANCIS I. AT ABBEVILLE.

THE use of carved wood in the ornamentation of houses was, in the fifteenth century, in general use in the north of France, and the western part of it, Normandy and Brittany, possessed works of art of admirable execution and of a very elevated artistic feeling. Rouen, Lisieux, Lanion, and so many other cities, in which this art has left traces of incomparable elegance, offer our decorators perfect models that leave to their initiative a free latitude to take inspiration therefrom without tying themselves down to the making of servile copies. Abbeville is among the best provided of the artistic cities of France. To speak only of carving upon wood, the church of Saint Wolfram has a porch whose wooden door is very curiously ornamented. It represents the Virgin and the twelve apostles. The reredos of Saint Paul, a triptych representing the marriage of the Virgin, the annunciation and the nativity, is a piece that it would be impossible to pass over in silence; and the religious structures of Abbeville possess other specimens of this epoch, in which the national art shed its splendors with profusion ere it disappeared before the intrusion of Italian art. Civil architecture likewise covered itself therewith, and with the more haste, it seems, in that the end of these admirable works was already felt to be at hand. Their condemnation had been pronounced and put in execution by George d'Amboise. It is necessary to be thankful to Francis I. and his successors, however, for not having destroyed the structures erected by French art and for not having entirely sacrificed to the Italian taste the admirable works in which the national soul had poured itself out. Thanks to this circumstance, comparison and discussion can now be established between the free Gothic expansion and the Latin formula, a work to which Mr. Courajod, the eminent conservator of sculpture at the Museum of the Louvre, has devoted himself, and for which he is not alone in fighting. To tell the truth, the provincial mind has always been faithful to that feeling of protection of works anterior to the Italian Renaissance, that is to say, of our true artistic patrimony. The passionate solicitude with which the majority of the archæological societies watch over these treasures has been their safeguard, and it is in this that we are still to find manifestations of art that are characteristic of us, a direct emanation, and without mixture, of the national soul. Thanks to it, elevated minds can now hope that French tradition will be renewed, and that our country will reenter into the possession of an art that in the future will permit it to be no more denuded of artistic riches than are the other peoples of Europe and those of Asia.

These reflections are applicable to all the works, large or small, that the four last centuries have allowed to endure—to the cathedral as well as to the piece of sculpture ornamenting the door or the gable of a house. Alongside of Saint Wolfram, the stairway of what is called the house of Francis I. has its importance, in that it also is an authentic witness of the decline of Gothic art.

According to Mr. Ris Paquot, an archæologist to whom the riches of Abbeville are familiar, this stairway is not in the place that it first occupied. It must have formerly belonged to one of the faces of an anterior structure, the substructures of which still exist, and must have given access to the upper stories. We must, therefore, have before us the lower part, with the regret that we cannot determine what the crowning was.

Our engraving represents the entrance door of the stairway and a portion of the cage. The sole leaf of this door is divided into four panels of a decoration formed of the apposition of two ogee arches. In the center we remark some figures formed by a crossing of letters connected by a funicular ornament. Mr. Ris Paquot sees therein the following couplings in Gothic letters: ny, ps, by, or hy, upon the panels of the staircase as well as upon those of the door. The funicular ornament, according to him, must relate to the order of chivalry created by Anne of Brittany in memory of her father, Francis II., Duke of Brittany, and designed especially for maidens and widows.



HOUSE OF FRANCIS I., AT ABBEVILLE.

The door is framed with carved jambs and with a lintel in the ornamentation of which appears the ogee arch. The finial of this arch carries a handsomely worked pedestal upon which stands a statue of the Virgin. This motif terminates in a canopy of an openwork flamboyant style, and rests upon an impost of the same decoration. At the left of the impost springs a corbel provided with a canopy like the first.

The case of the stairway exhibits three panels ornamented, like those of the door, with figures, ogee arches and festoons. They are separated by small columns of exquisite delicacy. Only three of these columns are visible, the others being hidden by the facade of a house standing in a sort of vast passageway. We are not certain as to the reason why the name of Francis I. is attached to this house. He made various sojourns at Abbeville both when he was but as yet merely Duke of Angouleme and after he had become King of France. Everything leads to the belief, however, that the house at which he stopped has entirely disappeared and that this stairway alone legitimately consecrates the memory of the King, in this part of Abbeville, if it really belongs to the house that has disappeared. The name under which it has been preserved has certainly a raison d'etre that it belongs to archæologists to discover.—Le Magasin Pittoresque.

THE GREAT BLUESTONE INDUSTRY.*

HOWEVER unhappy New York City may be in the matter of pavements between curbs, there is one fact apparent to the most casual observer, and that is that New York has the finest and best sidewalk pavements of any city in the universe. This is due to the fact that the sidewalks are largely paved with huge flat slabs of a natural product known in the commercial marts of New York as North or Hudson River bluestone. These slabs, which form smooth and dry platforms for the use of pedestrians, come from the quarries much in the same shape as they are laid upon the walks of nearly all of the Atlantic coast and many of the inland cities.

North River bluestone is a fine-grained, compact sandstone, extremely hard and wearing upon a tool, and is made up of microscopic crystals of the sharpest sand. It abounds in inexhaustible quantities in a belt of country reaching from the Helderberg Mountain, Albany County, in this State, diagonally across the southeastern portion of the State, and into Pike and Wayne Counties in Pennsylvania. The bluestone belt varies in width, being in the shape of a scalene or elongated obtuse triangle, no two sides of which are equal. In Albany County, at Reidsville and Dormansville, and Greene County, composing the northern extremity of the belt, the territory producing good marketable stone is narrow, being confined to the foothills of the eastern watershed of the Catskills and the southern slope of the Helderbergs. The stone quarried here is gray in color, with frequent tinges of greenish and light red and brown streaks, caused by the presence of calcite and ferric oxides. The stone is not regarded with favor by dealers, and brings a much lower price than the dark blue product quarried farther down the river. The industry is also a vanishing one here, for the top matter to be removed in the quarries has become so heavy as the strata dip into the hills that few quarries pay to work at the present price paid for flagging stone. Many of the best paying quarries of other days have been abandoned, and in consequence the ports of New Baltimore, Coxsackie, Athens, and Malden, particularly the last, have declined very much in importance since the shipments of stone have fallen off.

The bluestone belt follows the Hudson River until the town of Saugerties, in Ulster County, is reached, when it takes a westward drift, being interrupted on the east by the older limestone formations, and on the north by the quartzose and conglomerate or pudding stone formations of the Catskills, the latter of which undoubtedly rests on a foundation of bluestone, as it again makes its appearance on the westward side of the range. In the town of Saugerties the gray color of

* Henry Balch Ingram, in Popular Science Monthly.

the stone disappears, and the formation takes on the deep blue tinge whence it gets its name. Here also the belt begins to widen, and when the broad plateau at the foot of the Catskills, covered by the adjoining towns of Kingston, Woodstock, Olive, Marbletown, Hurley, and Shandaken, is reached, the quarries are distributed over a range of country at least fifty miles broad. Here the stone varies but little in color, touching only the shades from medium to dark blue. The presence of ferric oxides is found in all the quarries, but only in the seams on the surface of the slabs, which have a rusty color from the oxidation. The stone produced in Ulster County has always commanded the largest prices, it being the best quality produced in the entire belt.

Leaving Ulster County, the bluestone belt crosses the Catskills, takes in a corner of Delaware and Orange Counties, and then crosses Sullivan County until the Delaware River is reached, where quarrying is carried on all the way from Port Jervis to Narrowsburg on both sides of the river. Very little quarrying is done through the mountainous districts, although many quarries have been opened with a fair profit in Delaware County along the line of the Ulster and Delaware Railroad. The stone produced here, as well as along the Delaware River, is of a deep red color, contains large quantities of ferruginous matter, is of uneven texture, requiring more cutting, and is much inferior to the stone quarried in Ulster County.

The history of the discovery and first attempt to quarry bluestone for the market is shrouded in uncertainty. It is known, however, that a man named Moray opened a quarry at what has since been called Moray Hill, near Kingston, as early as 1826. His son, the late Daniel Moray, of Kingston, said that his father was the first person to put bluestone as a product on the market, drawing the stone to Kingston with an ox team and selling it for window sills and lintels. Phillip Van de Bogart Lockwood was the most prominent producer of bluestone for many years after this, hauling the quarried product to the docks at Kingston Point, where it was loaded on sailing vessels and taken to the New York market. Later on, Abijah Smith built a dock and bought stone at Wilbur, which he shipped to New York, and in the early fifties the industry became so important that a plank road, eleven miles in length, was built on the Ulster and Delaware turnpike through the quarrying country, for the better trucking of stone to the docks at Wilbur.

Some of the quarries have been veritable gold mines. One in particular, known as the great Lawson Quarry, at West Hurley, is said to have produced over four million dollars' worth of flag and other classes of bluestone. This quarry was worked by Lucius Lawson, now of Chattanooga, Tenn., for fully thirty years, and in it nearly two-thirds of a village of three hundred people earned their living. The great quarry has now been abandoned, as the top has got so heavy that it does not pay to remove it to get at the good stone. In consequence of its abandonment, the village of West Hurley has dwindled to less than one-third its former size, and is rapidly becoming a deserted village. Hundreds of other quarries have been abandoned for similar reasons, yet the whole bluestone district of Ulster County is thickly dotted with new quarries, which are opened as soon as the old ones are abandoned.

In working the quarries there is a great difference in the thickness of the slabs taken out. The formation exists in perpendicular blocks of different surface dimensions, which are formed of flat plates piled up like cardboard. The top of worthless stone and earth is first removed by blasting with powder, after which wedges are driven in the natural seams which separate the plates, lifting them up, after which they are hoisted out with derricks. In working a block the slabs may run to several thicknesses, varying from two to ten inches. The thin slabs are then cut up into what is known as corporation four and five foot flag and smaller sizes, while the heavier blocks are preserved intact for such huge platforms as we see reaching from building to curb line on the sidewalks of New York. Many of the blocks worked are so small in surface area that they are unfit for flagging, and are consequently worked up in coping, pillar caps, window and door sills and lintels, building and bridge stone for tramways. Other blocks are found suitable for curb and gutter alone, while some quarries furnish slabs so small and thin that they are used only for floor tiling or for the facing of brick walls. Again, some of the slabs, or more properly, platforms, taken from the quarries are from twenty to thirty feet square, ten inches thick and weigh over twenty tons. Owing to the difficulty in handling and the danger of breakage during transportation, these platforms are seldom taken to tide water, but are broken up at the quarries into more convenient sizes for handling. Sometimes, however, monoliths of tremendous size and weight have been transported to the docks at Wilbur, one being twenty by twenty-four feet in surface area, nine inches thick, without a flaw, and weighing several hundredweight over twenty tons.

It was quarried at the Sawkill, in the town of Kingston, and is said to be the largest stone ever brought to tide water. It took eight horses to haul this monster to the docks over a stone tramway, and it is alleged that the side of a tollgate had to be taken down to allow the stone to pass through. In quarrying bluestone much stone that is practically worthless is met with. Sometimes what looks at first glance like a fine, straight-seamed block will be uncovered, when, at the first attempt to work it, it will break up into small pieces like a pile of brick. These blocks are known to quarrymen as cat faces. This formation exists in small blocks between all good working blocks, as well as sometimes in the larger ones. Cat faces are worked up into blocks for street paving, many having been used in the Hudson River cities, where they are set so the wear cuts across the grain, and have been found to wear superior to granite block, as they never become slippery, and furnish always a sure footing for horses. The worthless stone of the quarries, called rubbage, is hauled to the dumps, where immense mountains of broken stone, often one hundred feet in height and several acres in extent, have been built up.

The quarrying of bluestone and its allied industries furnish employment at good wages to a large number of people. It is estimated that throughout the entire bluestone country—reaching from Albany County, New York, to the Pennsylvania region on the Delaware River—at least twenty thousand people get all or a portion of their support from the bluestone industry, while in the larger cities outside the bluestone belt hundreds of stonecutters are employed in dressing the stone. The wages run from a dollar and a quarter a day for common laborers to three dollars and a half a day for stonecutters, blacksmiths, tool makers, expert quarrymen, and other skilled labor. It would be hard to give a correct estimate as to the exact number of people who profit by the bluestone industry, as its influence is felt in all branches of mercantile trade, in lines of both water and land transportation, and in fact every industry throughout the district where the stone is found. To paralyze the bluestone traffic would mean to paralyze all branches of trade throughout that country. The bluestone trade amounts to nearly three million dollars annually, two-thirds of which is paid out in wages.

The manner of working bluestone after it leaves the quarries is worthy of notice. Before it is taken to the docks the stone receives only a superficial dressing. At the docks it is piled up, and such as is needed to fill immediate orders is sent to the cutting mills. Here the large slabs are laid on huge bed planers and planed smooth as a board. Others are sent to the saws, which consist of a gang of thin strips of plate iron, running horizontally over the surface of the stone. Under the edges of the saws, which are toothless, is kept a supply of wet sand very sharp in grain. The constant grinding of the saws in the sand soon cuts into the stone and rends it into slabs or bars of the required size. Other stone which is required to have a perfectly smooth surface is placed on huge revolving platforms of cast iron, the surface of which is kept covered with a thin coating of wet sand. The platform, revolving at high speed under the stone, soon rubs it smooth as polished metal—without the polish, however, as bluestone is not susceptible of polish. Other stone is dressed by hand by the stonecutters, who tool it with chisels and axes into different shapes. It is also turned in lathes in the shape of hitching posts, columns, and other forms, while it is susceptible of the most intricate carving, and is used at present in many classes of sculptured work for the ornamenting of buildings. Its extreme hardness makes it proof against all atmospheric changes, and it will neither shell like brownstone nor crumble like marble under the action of frost. It disintegrates and explodes, however, with terrific force under the action of intense heat.

The bluestone formation of New York State lying in Ulster County belongs to the Hamilton period, while that quarried in the other counties mentioned belongs to the Catskill group of rocks of the Upper Devonian age. As far as the writer has been able to learn, minerals are never found in the bluestone deposits, except in the form of oxides. Ignorant prospectors have at times reported the discovery of anthracite coal, which, however, has always proved to be a worthless deposit of organic slate, which in some localities abounds in considerable quantities. It is improbable that coal will ever be found in this region, as the stone formations that lie nearest the surface are those which underlie the coal measures of the entire country.—Popular Science Monthly.

[From the Boston Journal of Commerce.]

ARTIFICIAL SILK.

Among the processes which have been put forth from time to time for the manufacture of artificial silk, and the machinery used in connection therewith, those known by the names of Lehner and Chardonnet have been carried to the highest degree of perfection, and it is not too much to say, at the present juncture, says the Textile Manufacturer, that the former process is the one which is likely to attain the premier position, as being the most practical process of all that have yet been invented. We have recently witnessed a practical demonstration of the manufacture of artificial silk by this process.

Before describing the process in full we may say that the inventor is Dr. Friedrich Lehner, Ph.D., M.A., a well known chemist, of Zurich, Switzerland, who has made the production of artificial silk the subject of close study and unwearied experiment for the past nine years, and has now apparently succeeded in avoiding, rather than in overcoming, the difficulties which have hitherto proved fatal. There is no question that by his method a textile fiber of extreme fineness, with a tensile strength not much below that of silk, and with a brilliance and luster exceeding that of the highest qualities of silk itself, can be produced from materials of comparatively small value, by a series of processes, chemical and mechanical, and in themselves neither very complicated nor expensive.

To those who have not hitherto read particulars of the methods previously employed in the production of artificial silk it may be well to call their attention to the fact that they all start practically from the same base; that is to say, they take into account the fact that all vegetable fibers—such, for instance, as wood, flax, cotton and jute—may by a process of digestion—i. e., treatment by acids and alkalies—be reduced to what in the science of chemistry is known as cellulose. In other words, they become mere cellular tissue—the substance secreted by the living protoplasm of a vegetable cell in order to form its investing membrane or cell wall. Cellulose is indeed made from wood pulp, the debris from cotton, jute, and other spinning industries, etc., for a variety of commercial purposes. And it is this material which is the basis of artificial silk.

By direct combination with nitric acid it is converted into a nitrate, and if a small quantity of sulphuric acid be also added, the latter combines with the water, and to use a well understood chemical phrase, "splits off." The highest nitrates of cellulose are explosives, and are insoluble in alcohol ether. It is these nitrates which in various forms of modern explosives are familiar as cordite, tonite, etc. The pyroxylin nitrates, or lower nitrates, are less explosive, and are soluble in alcohol ether. Ordinary pyroxylin dissolved in alcohol ether (equal parts of alcohol and ether) is gelatinous in character, but wanting in viscosity. In other words, it will not, though a semi-fluid, flow freely. It is, in fact, not unlike good melted fish glue. A solution containing, say, more than 7 per cent. of cellulose is, however, too gelatinous to be readily workable, and in the Chardonnet process, before referred to, enormous pressure is resorted to in order to force the material through orifices sufficiently fine to produce a fiber capable of being spun. It is at this point where Dr. Lehner's special treatment of the pyroxylin comes in. By the addition of dilute sulphuric acid to the alcohol ether solution he breaks down the nitrate into bodies of different physical but of the same chemical character, and consequently is able to obtain a 12 per cent. solution which is perfectly fluid, and workable under the simplest conditions.

The preparation of this fluid, it will be understood, is so far a purely chemical one, and at the time of our visit was not demonstrated to us, though we think our readers will be sufficiently acquainted with this portion of the subject to know that the fibers above referred to can be digested or dissolved until they form a liquid as above stated. The liquid is of a yellowish color, but rather muddy, and to enable it to be spun or converted back again into a fiber it is stored in one or more glass vessels, as will be seen by reference to the accompanying illustration, which, we may add, does not do justice to the machine. The view of the latter is taken from the back of the frame, the spindles being farthest from the reader. The machine is a simple modification of a flier frame, and indeed it is the simplicity of the mechanism employed which tells very largely in favor of Dr. Lehner's process.

The supply of liquid in the glass vessels shown is kept at one uniform height, for reasons which will be obvious to mechanicians. To the underside of each vessel is coupled a glass pipe which passes downward and is connected to a horizontal glass pipe about three-fourths inch in diameter at the back of the frame. This pipe is provided with a number of glass nipples about 2 inches pitch apart, and to each of them is connected what Dr. Lehner has very aptly termed an artificial cocoon. This is merely a glass tube less than one-fourth inch in diameter, and is bent to the shape of the letter S.

Its free end is reduced to a conical form, and a very fine orifice is left in it, through which the fluid is forced by the "head" of liquid in the glass vessels. The lower ends of the artificial cocoons are submerged in a trough containing water, and as the fluid escapes the water removes about 60 per cent. of the solvent, with the result that the issuing streams of fluid immediately coagulate and are drawn off in exceedingly fine filaments of brilliant luster, and, when dry, of great tenacity. The filaments are at this stage nearly white, and each of them is picked up by the attendant by means of a wire hook and passed over a glass guide rod provided with small projecting nibs. At this point as many filaments as desirable to form the counts of yarn required—say six or more—are converged together and taken in this state to the drawing rollers of the machine. These merely consist of a bottom line of rollers with a line of separate weighting rollers above each thread, and they are rotated at a sufficient surface speed to keep the combined filaments at the required tension. From here the thread is passed to the flier and thence onto a double-flanged bobbin, the twist of course being imparted in the usual way, as will be readily understood by those engaged in the manufacture of other yarns.

In passing through the spinning frame the yarn rapidly dries, becomes quite solid, and in the process of drying the remainder of the solvent is removed. The yarn on the bobbins is practically indistinguishable from tram silk, except by microscopic or chemical examination. It is, however, in this condition, when perfectly dry, a highly inflammable substance, and it therefore requires to go through a third process—that of denitration—in which by a well known treatment by ammonium sulphide the nitric acid is extracted, after which, when the yarn is again dried, it is practically non inflammable. It is, indeed, less inflammable than cotton or rhea. Chemically the yarn when denitrated approximates very closely to silk itself. The lustrous character of the material depends upon its transparency and its cylindrical construction.

Cotton is not lustrous, because, although tubular, it is composed of a flattened membrane, which so breaks up the light that it appears to be quite dull. Flax, also tubular, is much more lustrous, and silk, which is a double tube, is, of course, incomparably beyond flax in this quality. The yarn can be spun of any count required, and one of the greatest advantages derived through this process is that the counts may be kept perfectly uniform. This will be obvious to our readers when it is understood that the cellulose nitrate can always be made of the same strength and in unlimited quantity, kept at the same uniform level in the supply vessels, the orifices in the cocoons kept the same size, and in these days of regular running engines, it is quite possible to run the spinning frame at a practically uniform velocity. In this respect the artificial cocoon is certainly a distinct improvement upon the natural type, for it is well known that the filaments coming from the latter vary very much in different cocoons, both with regard to their size and the difference in their state of health. Even in the same cocoons the diameter of the thread is larger at the finish than at the beginning of spinning.

A further point in favor of Dr. Lehner's process is that the manufacture of yarn can be carried on practically without attention, and we can certainly vouch for the fact that during about three-quarters of an hour's careful watching by our representative not a single end out of about 100 was seen to break. Some were broken purposely, to test the manner of piecing up, an operation which proved to be quite as easy, if not easier, than that of piecing cotton yarn. We were informed by Dr. Lehner that on some occasions the machine had been left running all night without attention, and in the morning all the threads were found intact. We give this statement for what it is worth, but our own experience is that it seems to be quite reasonable. Then, again, the process being chemical and mechanical, it goes without saying that no special conditions as to climate or temperature are involved, and the costs for labor and power are relatively so small to that of the chemical and other materials used, that the whole commercial question turns upon the value of these materials and of their economic manipulation. Hitherto, although the process has been carried long past the experimental stage, it has been carried out more on the scale of the laboratory than

of the manufactory, and it is obvious that with well-designed mechanical appliances and apparatus and a manipulation of chemicals on a large scale, very considerable savings may easily be made.

It will be interesting to our readers to know that samples of the artificial silk were submitted to the Bradford conditioning house, whose official report is as follows:

Bradford Corporation Conditioning House, June 8, 1894.

1. The samples submitted to me are purely artificial, containing no filaments of pure silk.

2. The relative strength, compared with Italian pure silk of the same counts (4,010 yards to the ounce), is as 68 to 100.

3. Pure silk has but little elasticity, and when stretched does not go back to its original length; neither does the artificial silk, but its stretching quality (before breaking) is as 73 to 100 relatively.

4. Taken at a denier, measure for measure, the relative weight of the same average diameters of pure and artificial silk is 7·25 per cent. more in the latter, which corroborates the relative specific gravities of each.

5. The artificial silk is much evener in counts (taking 20 tests of 10 yards each) than any pure silk.

6. The denitrated artificial silk takes the dye in all shades perfectly even and brilliant.

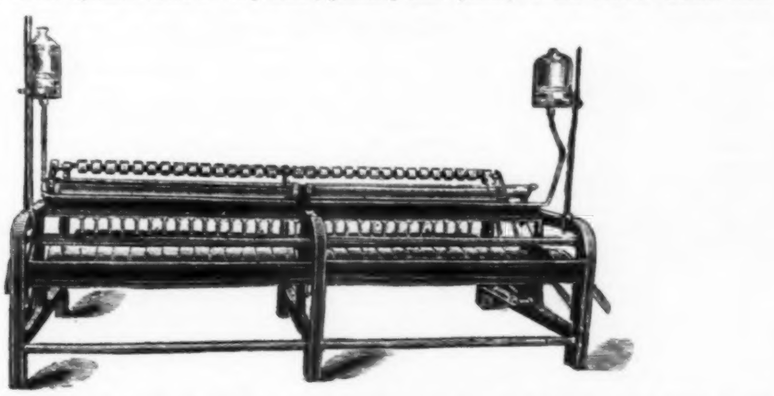
7. It stands boiling, washing off, and the use of either acids or alkalies equally well as pure silk.

8. The gloss or luster is equal to the best silk. Its appearance, and therefore decorative value, is far above spun chappe or combed silks.

9. In its denitrated state it is less inflammable than cotton, and perfectly safe for storing in quantity, either raw or dyed, and it is less inflammable than any sample of denitrated "artificial silks" we have yet tested.

WALTER TOWNEND, Manager.

Our readers will gather from the foregoing sufficient information regarding the fiber itself, and it only remains for us to say that we had ample opportunity of testing the strength of the fiber, and generally comparing its qualities with that of natural silk. This we were enabled to do by examining a large number of samples both in the form of hanks and in the woven state. The colors were, in our opinion, more brilliant in the artificial silk than in the natural, though, as before stated, the breaking strength is rather less. Partly for this reason it is not at present the intention to use the silk for warp, since the friction of the reed and also the shedding would have an injurious effect upon it. But in our opinion there is very little



drawback in this, because a vast quantity of silk goods are made with a cotton warp at the present time; and judging by the uses to which the artificial silk had already been put and the diversity of fabrics which had been woven with the silk used as weft, we think there is every reason to believe that artificial silk has a great future before it. We must, however, say that among the samples shown we did not notice any plush goods, though this was, perhaps, due to one of the reasons we have just stated. Still, we do not see why the silk should not be used for weft pile fabrics.

On the whole, we were highly pleased with our examination of Dr. Lehner's process, and it is only the barest justice to him to say that he allowed every opportunity for thorough investigation, and, along with several gentlemen interested in the manufacture, answered in a very satisfactory manner all the questions which were asked. From a commercial point of view, it is to be sincerely hoped that the artificial cocoon will give an impetus not only to the silk industry, which is in such a very bad condition, but will also open out new fields of enterprise to manufacturers in other branches of textile manufacture where the use of silk is at present but limited. This we believe it will do, if the wearing qualities of the artificial silk are as good as its manufacture seems to have been successful.

ON THE PREPARATION OF CARBON BLACKS FROM NATURAL GAS IN AMERICA.*

By GODFREY L. CABOT, Boston, Mass.

THERE is a certain small industry peculiar to the United States, of which, I think, no accurate account has yet appeared in any scientific journal or standard technical work, and which I am, therefore, encouraged to bring to your notice in the hope that it may at least have the charm of novelty to most of you. I refer to the manufacture of lampblack from natural gas. The substance thus obtained, known to the trade as carbon black, and also less frequently as hydrocarbon black, gas black, satin gloss black, jet black, silicate of carbon, and various other names, is collected on the under side of cast iron plates or rollers, from which it is automatically removed by suitable scrapers of iron or steel. This gas is burned from gas jets such as are used for illuminating gas.

As is the case with so many more important inventions, the merit of discovery has been claimed by different people and belongs to no one alone.

The first person who collected soot on a surface thrust into a flame made carbon black

* Read before the Scottish Section of the Society of Chemical Industry, Edinburgh.—From the Journal.

For the purpose of this sketch, however, the industry may be traced to certain printing ink makers in Philadelphia and New York, who found that soot thus made by artificial gas gave a beautiful gloss and intense color to printers' ink, differing totally in both of these respects from the lampblack obtained in the ordinary way by burning oily or resinous matters in an insufficient supply of air, allowing the smoke to settle in deposition chambers. A small amount was thus made in a private way at an expense of $2.25 to $3.10 per lb., till in 1872, or thereabout, Peter Neff, of Ohio, and Messrs. Haworth & Lamb, of Massachusetts, made experiments with natural gas for the same purpose, and the two latter erected in New Cumberland, Pennsylvania, the first factory in which carbon black was successfully made on a commercial scale. Others soon followed, too numerous to name, seeking thus to utilize the natural gas which was at that time going to waste in enormous quantities. This gas is always found with petroleum, and for many years it was chiefly regarded by the unscientific men who controlled the oil industry as a dangerous nuisance to be blown off and got rid of in every possible way.

The amount of this valuable and irreplacable substance which has been thus utterly wasted, it is impossible to estimate with any approach to accuracy, but I think I am perfectly safe in saying that it may be measured in hundreds of trillions of cubic feet. I myself have a well from which probably three billions of cubic feet of gas was wasted before any was utilized. Here, then, was an industry of which the raw material was natural gas, and the finished product easily paid for transportation over the worst roads.

The amount of capital required to start the business was comparatively small, and the price of the black high. The result was a crop of small concerns, most of which perished after a short existence.

Experience soon showed that the quality of the gas and its adaptability for making black varied greatly in different localities; that the duration of the supply was very uncertain; and that the average uneducated man, even though backed by Yankee push and ingenuity, did not possess the requisite engineering or business ability to invent, erect and maintain in successful operation the requisite machinery, nor to obtain and keep the requisite amount of trade.

The first factory erected contained a series of flat-bottomed cast iron pans arranged in rows and filled with water, which was supposed to improve both the quantity and quality of the black. Under each row of pans was a line of burners, ordinary gas tips, the flame of which impinged upon the iron and thus deposited the black. At intervals of 20 minutes a car traveled from one end of the row of plates to the other, supported on rails and drawn by a wire rope, and a scraper fixed in the open top of this car or traveling black box removed the black, which fell into the bottom of this car, and was thence removed by hand, bolted, and packed in barrels for market.

Of all the factories that have since been erected, perhaps no single one has used gas capable of producing so much black per thousand feet or of so soft a quality, and if there were any of this black still for sale, small quantities of it could be sold for four or five times the present market price.

The first lot of 500 lb. put on the market was sold for $2.50 per lb.; the next 1,000 lb. brought $1.50, and the factory paid for itself in three months. A year's output was soon contracted for at $1.25 per lb., but as competition increased the price rapidly fell. By 1881 black was selling at 35c. per lb.; by 1882 at 31c.; in 1883 an offer of 24c. per lb. for a 2,000 lb. lot was refused. Meanwhile various other methods of manufacture came into vogue. Many manufacturers tried cooling the depositing surface with water in various ways, and all abandoned it, including the original factory, it having proved that no material advantage was thus gained, either in quantity or quality, and an additional complication and expense, involving considerable mechanical difficulties, were thereby introduced. At first the great object of the manufacturers was to obtain the most intense color and the greatest gloss, and in this respect the original brand was soon surpassed, but at the expense of softness and opacity.

All carbon blacks bear a general family resemblance; are very intense in color, glossy whether rubbed in the dry or in varnish; have an extraordinary mixing strength, which, however, varies greatly and compares differently with lampblack, according to the medium in which they are ground with the diluting pigment; i. e., whether water, oil, varnish, or what not. Generally speaking, carbon black ground in oil with 100 times its weight of white lead gives a very dark gray, showing about three times the strength of a good lampblack and from five to ten or more times the strength of the poorer blacks.

They take twice as much oil to make a varnish of a given consistency as do ordinary lampblacks, but are much harder to mix, harder to dry, and more apt to curdle or form clots.

All carbon blacks will mix with water by simply shaking them with it; lampblacks, generally speaking, will not, and this is a convenient way of determining, in cases otherwise doubtful, whether a black is lampblack or carbon black.

The process originally used by Messrs. Haworth & Lamb is still in use in Sayenburg, Butler County, Pa., by their successors, Messrs. Nolen & Boardman. Peter Neff, of Ohio, was the next to enter the field, using a process somewhat similar to the first. His gas came from the geological horizon known as the Berea grit, and was poor in quality for the purpose of black making. He used no water, and shaped his benches slightly concave below, a doubtful advantage. His was the only factory for carbon black ever operated in Ohio and never exceeded an output of 125 lb. a day. It has not been in operation for two or three years or more.

The next process in point of time was the roller process, in which the collecting surface is a cylinder revolving on its axis. Various patents were taken out, and two or three factories were put in operation on this principle. It is very expensive both in cost of plant, repair, and consumption of gas, but is still used in one factory, and the black can be sold in small quantities at a high price.

When carbon black sold at 60c. a lb., it was thought by many that if it ever became equally cheap, it would replace the higher grades of lampblack made from oil, and, to a certain extent, it has; but there are some uses for which lampblacks are preferred, and there are brands which have remained practically unchanged in price for twenty years, and have increased the sale, at a price much higher than that of carbon black now.

Meanwhile the output of carbon black has been increasing at a very rapid rate, with a downward tendency in the price. In 1881 there was probably made from 400,000 to 500,000 lb., all of it on various modifications of the bench principle and the roller principle. In 1883, a new mechanism attained commercial success—that, namely, of a large plate, 24 feet in diameter, pierced with holes for ventilation, and revolving over stationary burners, and a stationary scraper, and a black box beneath it, from which last the black was removed by screw conveyers, and thus carried to the bolt, a cylindrical revolving sieve, through which the black fell to the bin beneath, from which it was lifted and packed by hand.

This machinery took the place of labor in sifting the black, and the loss in handling, due to the extreme lightness and fluffiness of the black, was diminished. As it comes from the sieve, the black is an extremely light, fine powder, weighing less than 5 lb. to the cubic foot. A gentleman, in conversation with a friend of mine, dipped his finger into a barrel of this unpressed black without noticing he had done so till his attention was called to it.

It will sometimes oscillate in waves almost like water, floating, as it were, on the air, which it mechanically imprisons. This may partly be due to its electrical condition from the friction of the scrapers working at a high temperature of 300° C. on a perfectly dry surface. The black is easily affected by electricity. If you rub sealing wax smartly on the sleeve and pass it over the black, it will fly up as if caught by a baby cyclone.

It is so dry and fine that I have seen it fly through a hole no bigger than a steel knitting needle, just as sand falls in an hour glass.

To transport it to Europe, or even shorter distances, it is necessary to compress it, which is a tedious and difficult job, far more so than with ordinary lampblack. The first successful packer was a screw press, worked by hand. To compress the black it was necessary to expel the air, and the difficulty lies in preventing the black spurting up with the air, which may be accomplished by covering the plunger of the press with a sheepskin, woolly side out. The wool retains the black, but permits the air to escape. A very important point is to shield the black from all air currents, from the time it is removed from the plates till it has been packed.

A slight air current will float away a considerable amount of black, causing loss and a nuisance.

In the years 1884 and 1885, small cast iron rings, rotated spasmodically by a ratchet mechanism, came into use as depositing surfaces. These are 8 feet outside diameter, 2 feet inside diameter, and have a ring of gas jets underneath them. This process was the invention of Mr. A. N. Blood, since dead. By it one-half of the total output of carbon black is at present made. It is customary to put these in rectangular buildings, flimsily constructed of sheet iron and steel, each containing 84 such rings in six rows, all actuated from a shaft outside the building.

The best output yet obtained is about 1 lb. per 1,000 feet. But I think there is at present no factory that reaches this average, and some not one-fifth of this.

Another process that has established itself, after five or six years of costly failure, is upon plates 24 feet or so in diameter, with gas flames and black box rotating beneath them. Another process, introduced in the year 1891, and in use at one of the two largest factories, consists of a series of small, independent, rectangular plates, with a scraper moving back and forward under each by a reciprocating motion. It is a noticeable fact that mechanical success or failure has depended more upon the skill with which the different methods have been applied than upon their inherent excellence.

Since 1885 most of the factories have been so arranged that the black is handled wholly by machinery. From below the bolt it is raised by an elevator to a large bin, out of which it is packed by machinery. An automatic modified flour packer, working on the principle of a screw propeller, has now come into general use

In 1886 the production reached 900,000 to 1,000,000 lb., and the price had sunk to 8c., although much was still sold at higher figures.

In 1889 some lots were sold that only netted the producer 3c. Since then the price has been better, netting the producers perhaps 7c. a lb. at the factories, on an average, for the last three years.

The output has meanwhile increased to about 10,000 lb. per day, and will amount this year to fully 3,000,000 lb.

The uses of the black are for printers' ink, paints, mineral black, stove polish, shoe leather, rubber goods, fertilizer, coloring cement, mortar pulp, and artificial stone, harness oil, stenciling, mixing with other blacks, such as lampblack, ivory black, etc., to improve their color.

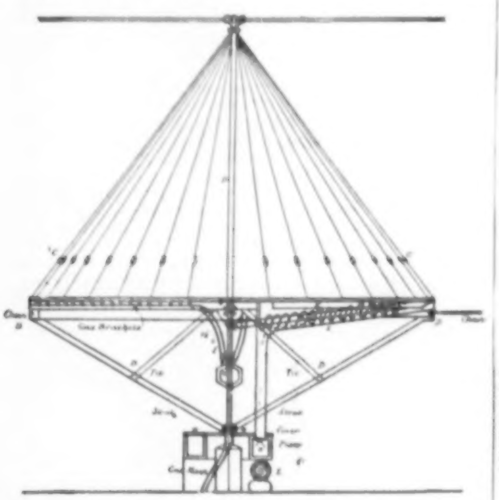
Chemically speaking, they contain 92 to 93 per cent.

of carbon, 5 to 6 per cent. oxygen, and 1 to 2 per cent hydrogen, and no trace of any mineral matter, nor have I ever known of gas black being adulterated, which I think is much to the credit of the trade.

DESCRIPTION OF APPARATUS FOR THE PRODUCTION AND COLLECTION OF CARBON BLACK FROM GAS.

A circular plate of cast iron 24 feet in diameter, A, cast in 48 pieces and carefully leveled, is hung to a 16 inch mast, B, a 3½ inch double extra strong tubing, by guy wires, C, tapped into a cup at the top of the mast and adjusted as to length by turn buckles, C. Beneath these, supported on pulleys at the foot of the mast and balanced by ties running horizontally to a collar on the mast, revolves once in 15 minutes or so a framework driven by a chain, D, at its circumference, and carrying a black box and scraper, E, a track of angle-iron for the chain to lie upon, and a gridiron of 1¼ inch pipe with from 700 to 1,400 gas burners such as are used for illuminating purposes, F, supplied from a 4 inch O D feed line, placed as near the middle of this gridiron as the mast, etc., will allow, and looking like the backbone of an unsymmetrical skeleton, G.

This feed line takes its gas in turn from a 1½ inch pipe, I, from a gas box rotating on a central mast, which is fed with gas from below. In the rotating black box is a screw conveyor, H, actuated by a pinion at the inner end, J, that engages in a small bevel box fixed on the mast. The black discharges downward from a spout into a circular trough-like box, K, shown in section in accompanying sketch, and from here it falls through a hole in the bottom into a long conveyor that carries it to the elevator, L, when it passes through a bolting machine made of very fine wire cloth, and is then



packed by machinery. On the circular box above referred to rotates a cover, M, and two cardinal points are to be noted:

1st. No draughts of air must touch the black at any stage of the manufacture.

2d. It is made and handled wholly by machinery up to the time that it has been packed; thus a uniform machine-made black of excellent quality is obtained.

NOTE ON THE ABOVE PAPER.

BY ROBERT IRVINE.

This manufacture is an adaptation of a process well known in England long before the discovery of natural gas in connection with the American oil wells. The same quality of black was made with similar apparatus, although on a much smaller scale, by printing ink manufacturers here 30 years ago, who employed ordinary town gas for the purpose. My own experience confirms Mr. Cabot's as to the quantity of gas required to produce 1 pound of black. Burning 1,000 feet of gas per hour the produce never exceeded 1 pound; and, of course, considering the price of town-made gas, this meant a first cost of at least 5s. per pound on the black produced.

This beautiful substance, with its velvet-like gloss, is quite different in appearance from lampblack made by burning oils. But as regards color value or covering power, there is between the two not the difference Mr. Cabot asserts. When the two varieties are reduced with, say, 100 per cent. of zinc oxide or chalk, the shade given shows very little difference between the two in color value.

Of course any idea of foreign competition with this American manufacture is out of the question, and America will hold the field until her resources of natural gas are exhausted.

With regard to the matter of price. Taking 7 cents a pound as the lowest price at which gas black can be delivered with profit in this country, as compared with the cost of black prepared from heavy dead oils (which yields 15 per cent.), we have the oil black at a cost considerably less than the gas black as at present imported.

Both of these blacks are contaminated by such bodies as chrysen and pyrene, which are of a dirty brown color; these dissolve in the varnish used for the manufacture of printing ink, and are apt to communicate this to the printed matter, and in process of time shows a kind of halo surrounding each letter. This is especially noticeable in old books or filed newspapers. These impurities can only be eliminated by igniting or calcining the black at a red heat.

It has often been suggested, and I believe has been tried experimentally, that the gas from the shale retorts in the oil manufactories in Scotland could be profitably employed for this manufacture; but considering the enormous quantity of gas required to produce this black, it is most probable that the shale gas can be more profitably employed as fuel.

The president said that this process was obviously only applicable where gas could be obtained for nothing. Even Glasgow gas at 2s. 6d. per 1,000, and containing more carbon than Edinburgh gas, would not pay to burn for the manufacture of carbon black.

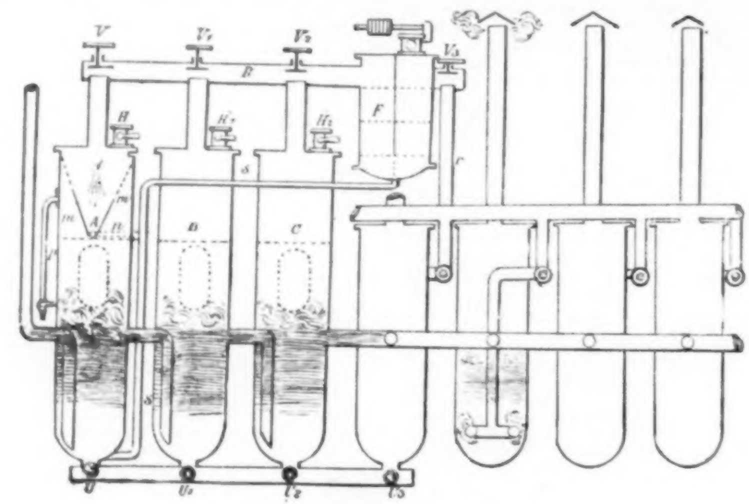
The form of press employed in packing this black was of interest, and he asked Mr. Irvine to further explain its method of use.

Mr. Irvine said that the light substance was first put into a barrel capable of sustaining a level pressure, and in place of using an ordinary piston, such as would be employed with a coherent substance, the front of the piston was covered with a sheepskin, the wool side outward. The wool allowed the air to escape but retained the solid black. The press worked admirably. Impressed black was so light that a large feather bed tick filled with it could easily be lifted with one hand.

PURIFICATION OF SUGAR—CONTINUOUS "FIRST SATURATION."

By T. FRANC, Zeits. Zuckerind. Bohmen, 1893, 18, 1—3.

SINCE animal charcoal has fallen into disuse the most vexed question with regard to the purification of the sugar juice is the "first saturation." The saturation gas employed must be as rich as possible in carbonic acid. On this account large lime kilns furnished with ingenious heating arrangements have been erected. Endeavors have especially been made on all sides to prevent as far as possible the great losses of carbonic acid which are occasioned by the use of the existing forms of saturation apparatus. Indeed, experiments with a gas containing 26 per cent. of carbonic acid proved that 9 per cent. of the saturation gas was lost at the commencement of the operation and 19 per cent. at the end. The present invention was devised to obviate this loss, and the author points out that not only is the latter object attained, but the work is expedited.



SUGAR PURIFICATION.

The "first saturation" is divided into two stages: (1.) A continuous preliminary saturation with the original gas. (2.) The employment of the gas which escapes from the first operation to finish the process.

Presuming the presence of a mixer, the juice, after mixing with lime, is led into the three high saturators, A, B, C, where it rises from the first into the second, and thence into the third vessel, a continuous flow of gas being maintained meanwhile. Both the inflow and the outflow pipes are furnished with valves. From these preliminary saturators the juice enters one of the finishing saturators. The gas evolved from the preliminary saturation passes through the pipe, R into the froth retainer, F, in the first division of which it takes a downward direction and in the second an upward direction, thereby destroying the froth, which is returned as juice by the tube, S, to the preliminary saturator, while the gas passes through the tube, r, to the finishing saturators. The tube, R, is furnished with valves, V, V_1, V_2, the tube, r, has likewise a valve, V_3. The finishing saturator has also an independent gas and juice delivery tube, so that when desired the saturation can be conducted in the old way. When, for example, the preliminary saturator, A, is being cleansed, the inflow valve is closed from the mixer, the juice run into the finishing saturator, and the operation conducted in the old way. The valves, V and V_3, are closed, while A is placed in connection with the empty finishing saturator, No. I., by opening the valves, U and U_3, and the contents of A forced into the vessel, No. I., by means of gas. The same applies to the cleansing of the other two saturators.

A SIMPLE METHOD OF DRAWING.

ENGINEERS, in whose work drawing and sketching play so important a role every minute, will certainly be interested in the method of teaching drawing just published by Mr. Paul Ravoux, of Remiremont. The "Interpretations pour dessiner simplement" (such is the title of the work) tell the beginner what he must do in order to at once succeed in drawing. To this effect, the author has devised a graduated series of lines from which he makes the most varied forms proceed. He thus effects the reduction of the complex forms of nature to a few simple geometrical data.

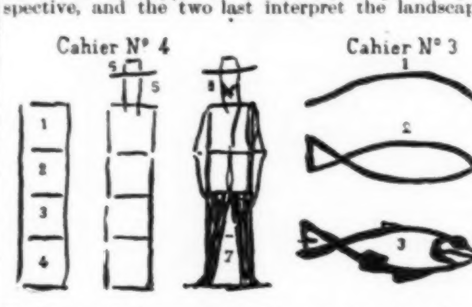
This sort of study necessitates but little explanation, the sight alone allowing the natural order in which each line must be placed to be understood. So the student, encouraged by his unexpected success, quickly gets a liking for the practice of this sort of work, and soon retains the principles of the figures that he has drawn. These figures are, as far as possible, composed of squares, triangles, circles, angles and oblique and vertical lines.

The pupil fixes these in his memory with pleasure, and is not repelled thereby, as he would be by dry notions of nomenclature. He thus, without any trouble, learns a language that he will later on know how to speak perfectly.

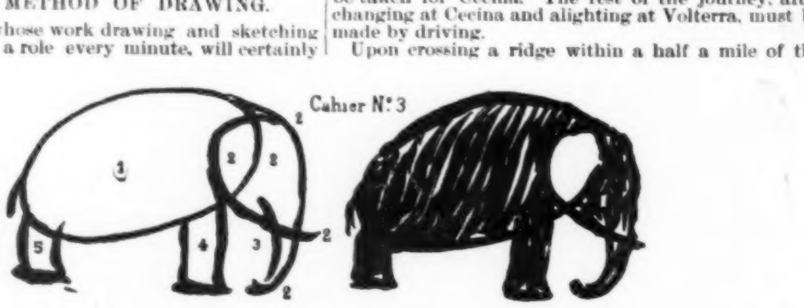
This language of drawing, as Mr. Ravoux shows, corresponds in many respects to the spoken language. One makes use of letters that it forms into words and then into sentences, in order to be the expression of a thought, while the other assembles its lines into circles, squares, angles and triangles, and combines these squares and these other figures according to established proportions, in order to translate a collection of more or less elevated ideas, and these two languages may harmonize and render the same subject with an equal art, provided that the study thereof has been regular and rational, and that a certain talent, a gift of nature, has been awakened by practice and instruction.

It is in this order of ideas that Mr. Ravoux offers these "Interpretations" to the public as a certain and attractive guide, which is assuredly capable of rendering services to the cause of the teaching of drawing.

The method is distributed through eight books, in which are studied the most diverse objects taken isolatedly or grouped in series. Two of these books are devoted to the application of the principles of perspective, and the two last interpret the landscape.



The figures that accompany this note show the advantage that may be derived from this analytical method of drawing.—Le Genie Civil.



THE LARDARELO BORIC ACID WORKS.

IN a paper describing these works read before the Baltimore Section of the American Chemical Society, Mr. William P. Mason says so far as he is aware no recent description of these famous works has been given, and there is certainly widespread ignorance as to the best route by which to visit them. The most convenient starting point is Pisa, whence a train may be taken for Cecina. The rest of the journey, after changing at Cecina and alighting at Volterra, must be made by driving.

Upon crossing a ridge within a half a mile of the end of the journey, the boric acid plant, and its attendant village, suddenly come into view, and, with the numerous jets of native steam rising from and among the buildings, the resemblance is very strong to a busy New England factory town.

All of the district now covered by the works was originally owned by the people of the neighboring

ancient town of Monte Cerboli, but having been held by them as of little value, it was very cheaply obtained in 1818 by a poor young Frenchman, who detected the presence of boric acid in the steam, and who was shrewd enough to appreciate the value of his discovery. He at first formed a company for the purpose of developing the property, but later acquired entire possession himself.

The boric acid, to the extent of one-tenth of one per cent., is contained in the native steam that issues from the earth through numerous orifices, all of which have been tubed to a greater or less degree.

These tubings are mostly of eight inch pipe, and extend into the earth of varying distances, some a few feet and others over three hundred. Certain of the fumaroles are entirely artificial, having been bored after the manner of artesian wells. The boring tool, when it reaches the steam zone, usually drops suddenly a yard or more, and immediately thereafter steam escapes with much force. The temperature of the issuing steam varies in the different outlets from 98°–140° C., and it rushes from the pipes with great noise and power.

Ordinary spring water is led into a circular brick cistern about thirty feet in diameter, and an eight inch pipe, conducting natural steam, passes through the cistern wall about one foot below the water surface.

The issuing steam, which impregnates the water with boric acid, causes a fountain of several feet in height to play in the cistern.

After an interval of twenty-four hours the contents of this cistern are piped into another similar one on a lower level, and are then subjected to a further injection of steam for an additional twenty-four hours, after which the solution passes to a square settling basin, where a grayish mud, of exceedingly fine state of division, separates.

This mud, which contains more or less boric acid, is given away to the country people, who use it as an application for diseases of the hide occurring among sheep and cattle.

From the settling tank the boric acid water passes to evaporating pans (forty in number) made of lead. These pans are six feet wide, 150 feet long, and eight inches deep. They are slightly inclined, and are divided by small ridges two and a half inches high crossing them transversely every two feet. The liquid enters at one end and slowly flows over the step-like divisions to the other, the rate of inflow being made equal to that of evaporation.

When, in the judgment of the attendant, the concentration has been carried far enough, the flow is cut off, and the hot concentrated liquor is brushed out by brooms into crystallizing tanks, ten by thirty feet in size, and allowed to cool.

The deposited crystals of boric acid are removed by wooden scoops, drained in baskets, and the mother liquor is returned to the evaporating pans.

The crystals are spread upon a steam-heated drying floor protected by a shed-like building thirty by fifty feet in area, and when dry are placed in bins for storage. Shipment is made in casks holding about 1,000 pounds each. The heating of the evaporating pans and drying floor, in short heating of every description throughout the establishment, is by native steam.

About 200 hands are employed in the works, and the annual output is approximately 1,700 tons, all of which is shipped to England, via Leghorn.

Count Lardarel appears to have a careful eye for the welfare of his employes, as is evinced by the substantial manner in which the village is built, its cleanliness and the attempts made to adorn the streets. He was awarded a medal at the Paris Exposition for his contributions toward the betterment of social conditions, in addition to an award made for his manufactures.

BOAT WITH PROPELLING TURBINE.

THE idea of replacing the wheels and screws of steamboats by another arrangement derived from the same principle, that is to say, by a turbine acting like a wheel, but in a closed space and upon a limited quantity of liquid, is not new. Born in America, with Rumsey, it has been taken up in England by Ruthven and in Germany by Seydel. But none of the tentatives made by these engineers has been crowned with success. Lately the question has been resumed, and the serious experiments made by the Elbe Navigation Company merit fixing attention upon this new mode of locomotion, which may have a certain future.

It is Mr. Zeuner, a German engineer, who has

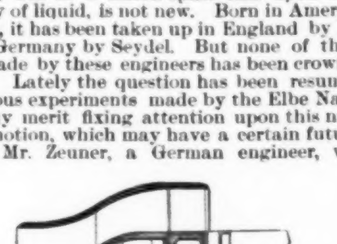


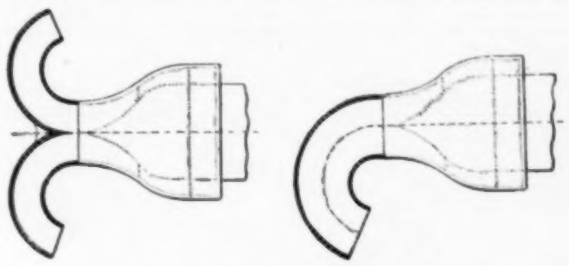
FIG. 1.—CONTRACTOR.

studied the question anew, and three boats have been constructed upon the Elbe by the company according to his calculations. We take the following description of them from the Zeitschrift des Vereines Deutscher Ingenieure:

Mr. Zeuner first tried to find out to what the want of success of his predecessors was due. The latter took the water at the base of the boat at right angles with the direction of motion. The suction was effected with centrifugal pumps, in which the water was submitted to a high tension, which developed again the exit orifices, wherein resistances were created at the abrupt bends of the apparatus. The loss of work was therefore considerable. Mr. Zeuner was led to the conclusion that the three principal conditions to be realized would therefore be the following: (1) The channels for the circulation of the water should not present abrupt curves; (2) the water should enter according to the direction of the motion and preserve such direction at the exit, to as great a degree as possible, after having passed into the suction apparatus; (3) the water should enter through the very motion of the boat, and should undergo but a slight modification of velocity.

Such are the conditions that he sought to obtain for the construction of the Elbe boats.

He first replaced the centrifugal pumps of his predecessors by turbines of the Henschel-Jonval system; and then, as the passage of the water into the turbine was not sufficient to effect a motion, he fixed upon the body of the turbine an ajutage, provided with float boards for a portion of its length, in order to lead the



FIGS. 2 AND 3.—REVERSING APPARATUS.

water, without shock, to the orifice (Fig. 1). The section was slightly less at the exit than at the entrance of the turbine, so that there was a feeble acceleration of velocity. The apparatus thus arranged is, therefore, capable of operating like a pump, and calculation shows that there is a variation of pressure that explains the motion of the water toward the orifice of discharge. There is a suction of the water, just as in a mine ventilator there is a suction of air.

Such is the principle of the new apparatus.

There remained another question to solve, and that was the backward running of the boat. It was impossible to think of changing the direction of revolution of the turbine, after the addition of the ajutage above mentioned. The running, therefore, had to be modified without in anywise changing the direction of motion of the steam engine. It occurred to Mr. Zeuner to provide the orifice of discharge either with a double ajutage of 90° (Fig. 2) or a simple curved one of 180° (Fig. 3), both permitting of the escape of the water in a direction opposite that of the entrance. The change of direction can then be effected by putting on or taking off this ajutage. This, besides, has the advantage of allowing the engine to revolve at a constant velocity without any slowing up.

It was according to these studies of Mr. Zeuner that the Elbe Navigation Company built its three experimental boats, the Fee de l'Elbe, the Merle, and the Saxe.

Some comparative experiments were made with the first named of these boats, by employing in the first place, as a mode of propulsion, a screw 0·69 m. in diameter, and then replacing this screw by a Zeuner apparatus calculated according to the resistance of the boat. This apparatus had the following dimensions:

Mean radius of the turbine	0·220 m.
Width of float boards of the turbine	0·134 m.
Height of float boards of the turbine	0·110 m.
External diameter of apparatus	0·574 m.
Diameter of exit orifice	0·315 m.
Number of float boards of the turbine	20
Number of float boards of the ajutage	16
Cube of water per second	0·654
Theoretical velocity at entrance	4 m.
Theoretical velocity at exit	7 m.

The principal dimensions, etc., of the boat were:

Length at the load water line	12·5 m.
Maximum breadth	2·2 m.
Draught of water amidships	0·75 m.
Displacement	10·55 ³m.
Surface submerged at the loadwater line	20·86 ²m.

The first experiments with this boat were made upon the Elbe, between Dresden and Wachwitz, upon a course of 4·531 meters.

The experiments with the screw were made on the 5th of September, 1891, and the others on the 21st of June, 1892. The results were as follows:

Nature of motor.	Direction of running with respect to current.	Speed.	Revolutions per minute.	Work.	Low water.
Screw	Downstream	4·820	365	25·74	0·87 m.
	Upstream	2·766	358	23·76	0·87 m.
	Mean	3·793	358	24·70	0·87 m.
Turbine	Downstream	5·036	302	22·55	0·46 m.
	Upstream	2·862	304	22·55	0·46 m.
	Mean	3·944	304	22·52	0·46 m.

Other experiments were made in running forward and backward, but under bad conditions, in that the apparatus employed was not sufficient for the resistance of the boat. The results of the experiments were as follows:

Motor.	Direction of running.		Speed.	Revolutions	Low water.
Screw	Forward	Downstream	4·820	365	0·87 m.
		Upstream	2·766	358	0·87 m.
		Mean	3·793	358	0·87 m.
	Backward	Downstream	3·422	not observ'd	0·87 m.
		Upstream	1·961	289	0·87 m.
		Mean	2·692	289	0·87 m.
Turbine	Forward	Downstream	4·807	390	0·72 m.
		Upstream	2·765	390	0·72 m.
		Mean	3·786	390	0·72 m.
	Backward	Downstream	3·424	507	0·82 m.
		Upstream	1·216	529	0·82 m.
		Mean	2·320	529	0·82 m.

The Merle was not utilized in special experiments, but performed a regular service that permitted of comparing its speed with that of the screw boats. It attained the mean speed of the latter, and was capable of giving, during the summer months, for example, a speed of 3·5 meters per second with two meters of water.

It was in the fall of 1892 that the Saxe was constructed. Its principal dimensions are as follows:

Length	33·5 m.
Maximum breadth	3·7 m.
Draught	0·65 m.
Displacement	52 ³m.
Surface submerged	90·7 ²m.

The boat was provided with two Zeuner apparatus placed on each side near the center, and presenting the following dimensions:

Mean diameter of turbine	0·25 m.
Width of float boards of turbine	0·142 m.
Height of float boards of turbine	0·15 m.
Diameter of exit orifice	0·387 m.
Number of turbine float boards	20
Number of ajutage float boards	13
Cube of water per second	1·3 m.

The boat had been calculated to give a speed of 5·5 meters in deep and still water. It gave 5 meters commercially. This is an appreciable result.

Finally, on the 4th of March, at the time of a rising in the Elbe that carried the height of low water to 1·13 meter at Dresden, it was possible to make the trip between Kaditz and Kotzenbroda with a speed of 7·08 meters in descending and of 3·4 meters in ascending, say a mean of 5·28 meters. The turbine made 270 revolutions per minute.

It seems, therefore, to result from these quite numerous experiments that a vast field is open to researches with a view to improving a new mode of propulsion which is to have a future. From the standpoint of mechanics, the idea is perfect, since we disturb a fraction solely of the liquid that produces the motion; with screws or wheels, on the contrary, we lose much of the useful effect, as a large mass of water is still agitated behind the boat without furnishing any work. From the standpoint of speed, we shall obtain good results, since upon a large boat we can multiply the Zeuner apparatus to infinity, and have powerful steam engines making a constant number of revolutions without any reversing apparatus. Such engines, with an equal amount of work, will give a greater speed than in steamboats. From the standpoint of stability, we avoid the jarring of the wheels or screws, and there are no variations in the line of submersion. As an offset, oscillations upon the sea may raise the turbines out of water and make them suck air, which would much interfere with the operation of the apparatus. So it will require still other studies and numerous experiments before we see large ships provided with the apparatus that we have just described.—Le Genie Civil.

ALUMINUM BOATS.

AMONG the many advantages presented by the use of aluminum, says the Engineer, its suitability for the construction of light boats is one that has often been recognized, and has especially been borne in mind in the equipment of Arctic expeditions. Our readers will remember that a couple of boats of this kind formed part of the equipment of the recent Wellman expedition; and at the Grafton Gallery on July 7 there was on exhibition a similar boat which excited some interest.

The boat which is shown, holding twelve men, is 18

ft. long, 5 ft. beam, 2 ft. deep, and can carry two tons; and with sails and masts weighs 192 lb. It is built in three sections, as shown. The two end sections are interchangeable, so that the boat may be sailed either way; or if desired the end sections form a complete boat, as shown, in which form, filled with stores, it is designed for their conveyance on sledges across the ice. The whole is covered inside and out with Messrs. Docker Brothers' non-corrosive paint, which is impervious to the action of sea water.

Each section has a waterproof canvas covering stretched tightly over the top, perforated with holes with bag-like fittings for the rowers to draw tightly under their arms, each section thus forming an absolutely watertight compartment. All the metal fittings and wire ropes are of aluminum, and the basketwork fenders, which keep off the floating ice, when not in use fold in the bottom of the boat, are to be used to sleep on, and while the middle section forms one sleeping compartment, the others when placed on end and

facing one another make a small tent. The bamboo mast is also in two parts, so that it can be stored away when not in use. The cooking utensils are also made of aluminum. The makers are Messrs. Swain & Kirby, of Birmingham.

[From the Colliery Engineer.]

A TYPICAL GOLD MINE.

By Prof. Arthur Lakes, Golden, Col.

We were in search of a well-developed typical gold mine to describe for the readers of the Colliery Engineer, from grass roots to completion. We found just what we wanted in the Standley Consolidated Mine at Idaho Springs, Clear Creek County, Col.

In going to study a mine or mining region, it is a good preparatory lesson to study as well as you can the formations of the country on the road to it.

Our course took us up the grand defile of Clear Creek canyon, cloven by glacier and stream into the heart of the Archean granitic range to a depth of over 1,000 feet.

The walls of the canyon we observed to be formed of gneiss, or stratified granite, and dark schists. These strata have been violently uptilted, folded up into arches and thrown into most intricate contortions; also fractured, fissured and broken. As we glide along in the train we notice that a series of fissures descend the walls on either side at varying intervals, preserving a rough parallelism to one another. There appear to be two sets of these fissures, or great joint planes, cleaving the whole mountain system. One in a direction northeast by southwest and the other about east and west, or more strictly, a little southeast by northwest. These fissures occasionally bisect one another diagonally. Some of these fissures are still open cracks, the walls seldom more than a few inches or a foot or two apart. Others have been filled up and healed by a crystalline mixture of pink feldspar, quartz and a little mica, which appears to have oozed in in a plastic condition from the walls and material of the bounding country rock.

These are the veins or so-called fissure veins of the region. One thing, however, strikes us, that despite the great number and often great size of these red veins, all of them appear to be barren, since there are no developments upon them for the first twenty or thirty miles between the plains and Idaho Springs, the first mining town. We look for the reason of this, and find it, we think, in the total absence throughout this interval of any eruptive volcanic rocks, or any dikes or sheets of eruptive porphyry. On the other hand, when we reach Idaho Springs, we find porphyries abundant and in close relation to the ore bodies. It is held as a maxim in Colorado generally, "No porphyry or no volcanic rocks, no ore." Ore deposits seem with us, at least, inseparable from the presence of eruptive rocks in the neighborhood.

At the pretty little town of Idaho Springs we emerge into a basin hollow in the mountains, formed by the ancient glaciers and apparently the site of a once glacial lake. Here are signs besides porphyry, which would suggest the probabilites of ore deposits in the vicinity, viz., the presence of numerous living hot springs, and on the cliffs evidences of old ones. Hot springs are generally to be found in the vicinity of a mining camp in Colorado, being relics of old, long dead volcanic action.

Passing through the town about half a mile up the canyon, we come upon the mills, buildings, plant, etc., of the extensive property of the consolidated Standley, situated on the banks of the stream; while on a large vein standing out here and there in relief on either side of the canyon clear to the tops of the mountain are located at intervals the old and new dumps and tunnels and houses of the mine. On the north side of the creek we see along the course of the vein a series of narrow, open, gaping fissures. This is where the ore and the vein have been worked or stoped out clear to the surface. We observe, too, that the main vein has been crossed by other veins diagonally, some of which have been worked. Clear Creek flows through the center of the canyon, and in the far distance at the canyon's head is a glimpse of the Snowy range and the Georgetown mining district. The steep sides of the cliffs and the banks of Clear Creek give good dumping ground, while the river supplies ample water power, two important desiderata in the location of a mining property, and the broad, flat tops of the river banks are well adapted for the location of the mining plant and houses.

THE STANDLEY MINE.

The Standley Consolidated Mine is located on both banks of Clear Creek, about a mile above the mining town of Idaho Springs, about 40 miles from Denver by the Union Pacific Railway, which runs up the canyon and through the property on the north side of the creek. The altitude of the mine is about 7,600 feet above the sea, or about 3,000 feet above Denver and the plains.

The geological formation is Archean gneiss and schist, traversed by many large masses of a coarse crystalline granite, forming large irregular segregative veins of pegmatite, i. e., coarse sparry crystalline granite of feldspar and quartz, with very little mica. These veins are irregular in shape and character, especially the smaller ones. Sometimes they are only a few inches wide and long; at others 50 feet or so wide, and cleaving the mountain sides from top to bottom, easily distinguished from the country rock by their light pink color and from their hardness, standing out in relief above the surrounding rock like great red dikes. The course of the main system of such veins is N.E. by S.W., while another less powerful set cuts them diagonally.

Fig. 1.—VEIN PHENOMENA.

H. W., hanging wall; F. W., foot wall; R. O., rich ore; C. O., concentrating ore; Q. F., quartz, feldspar, etc.

The hills adjacent to the mine were formerly well timbered, but most of the wood has been cut for the mines. Good pineries and saw mills are abundant a few miles back in the mountains.

The bulk of the vein, which extends up the faces of both mountains and under the creek, was until the past few years known as the Hukill and Whale, the Hukill occupying the north bank of the creek, and the Whale the opposite or south side.

The original owners thought that their claims covered the whole of the vein on both sides of the creek from mountain top to mountain top. But the present owner discovered, by examining the maps, that a large part of the vein near the top of the mountain on the south side, owing to a mistake in observing the direction of dip in the vein, was not included in their location, so he located on the Aspen above them and opened upon the top of the mountain the Standley mining shaft. This is a double lesson; first, be careful in locating your claims; second, that good prospects and extensions in quite an old, long settled camp may yet be found by those who look for them.

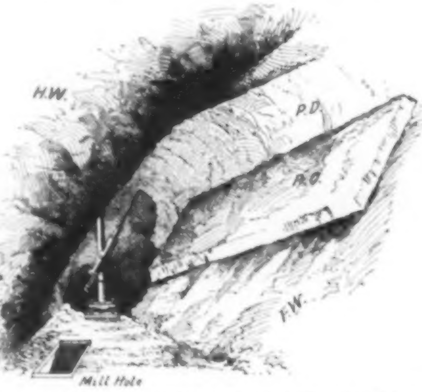


Fig. 2.—CONTACT VEIN IN STOPE OF THIRD LEVEL.

After working the Standley for some time, the owner by surveys and measurements began to suspect that some of the workings of the Whale (probably without the knowledge of owners or men) were, and had been for some time, trespassing on the side lines of the Standley property. To prove this he opened a shaft on the vein at the extreme limit of his side line, down the hill, and probably to the surprise of both parties the shaft one day broke into the middle of the Whales' tunnel.

A compromise was attempted, resulting in the present owner buying out the old mines and uniting Whale, Hukill and Standley in one property known as the Standley Consolidated.

HISTORY OF THE MINE.

It is probable that the mine was discovered at an early date by the old Spanish residents, in working a placer called Spanish bar in the bed of the creek near where the vein crosses. This placer ground just below the vein, and right up to it, produced large quantities of gold, though strange to say the surface matter of the vein was quite poor in gold. The bold outcropping of the vein would hardly have escaped the eyes of the early prospectors, particularly as its course was freely stained with iron and green carbonate of copper. A Colonel Damont at one time took hold of the property, and later, parties of Comstock fame under the names of the Hukill or Plutus and Whale developed it Comstock fashion.

At the first development of the vein the prospect does not seem to have been very promising. The surface of the lode showed very little value, and it was not till many thousands had been expended that it became productive. As depth was gained the ore became more solid. In the Whale and Hukill little or no lead ore was found. But in the Standley a great lead zone was found, which in depth became the usual iron and copper pyrites. The silver values were greatest in the upper workings; with greater depth the silver diminished and the gold increased. Ore from the upper workings averaged 70 to 100 ounces silver per ton, and $1.50 to $1.75 gold in the lower workings.

The ores at present are dry quartz ores, mainly composed of iron and copper pyrites, together with purple copper or bornite, and bright, iridescent hued copper, known as peacock copper. There is not much free gold in the mine, nor does it appear there ever was, even at the surface, where it is generally found most abundant. The gold values increase with depth, especially at the bottom of the shafts; while laterally lead ore is found near the surface. Over two-thirds of the developed ground has been productive. The vein has been opened for over 3,000 feet continuously, and prospected on the surface for 3,000 feet further.

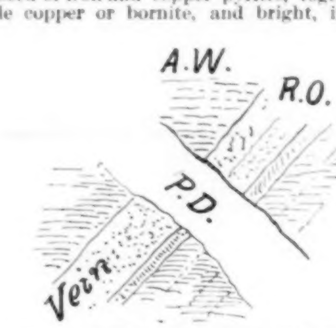
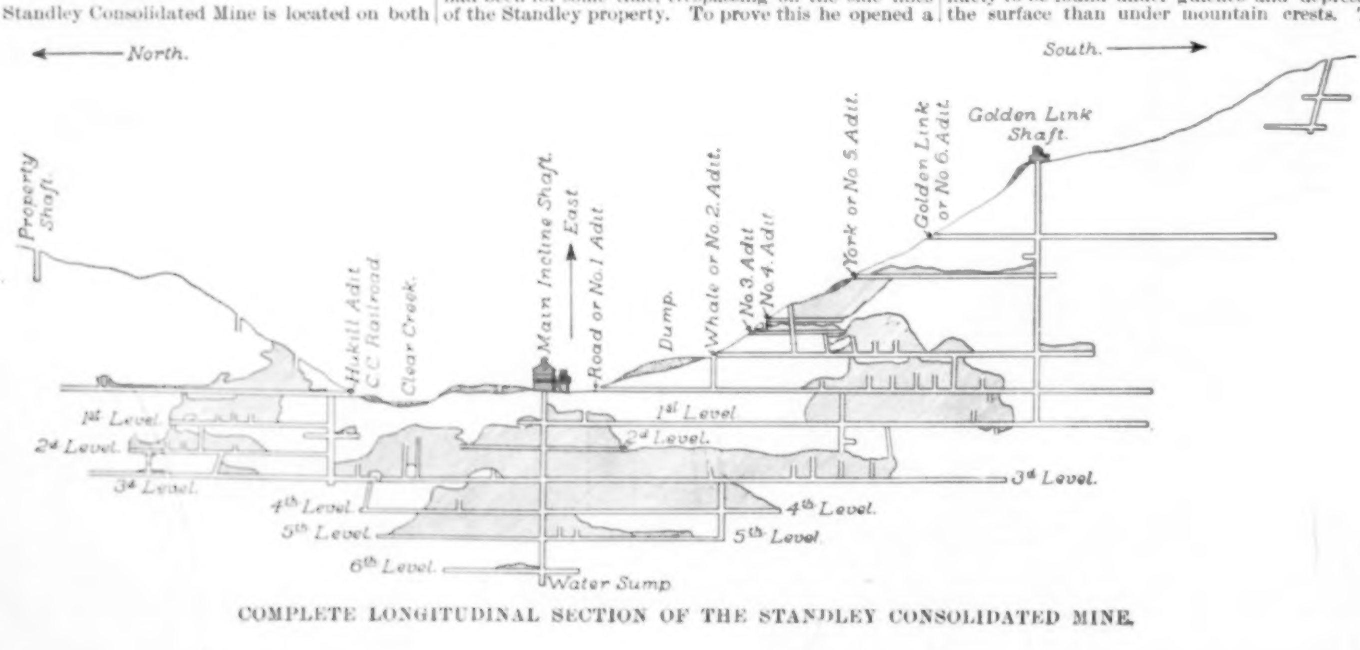


Fig. 3.—VEIN FAULTED BY PORPHYRY DIKE, THIRD LEVEL.

There are 14 lode claims, 6 placers covering 7,000 feet of the vein and two miles of the creek. There are five principal ore chutes, or zones of principal mineral deposit on the vein, with average intervals between them of 200 to 250 feet. These ore bodies are more likely to be found under gulches and depressions on the surface than under mountain crests. The ore



COMPLETE LONGITUDINAL SECTION OF THE STANDLEY CONSOLIDATED MINE.

averages in silver 30 to 40 ounces per ton, and the gold 2½ to 4⅛ ounces. Some of this ore being poor and low grade and mixed with much rock is a concentrating ore, and some of it goes direct to the smelter. The average assay value of the present ore is:

FIRST CLASS.

Silver in copper ore	35	ounces.
Gold	2½	ounces.
Silica	26	per cent.
Iron	24	per cent.
Copper	5	per cent.

SILVER IN LEAD ORE WITH NO ZINC.

Silver	25	ounces.
Gold	1⅛	ounces.
Lead	30	per cent.
Silica	20	per cent.
Iron	15	per cent.

CONCENTRATES.

Silver	20	ounces.
Gold	2	ounces.
Iron	23	per cent.
Silica	16	per cent.

CHARACTER OF THE VEIN.

The vein would popularly be classed as a so-called "true fissure vein," but if by this is meant that there

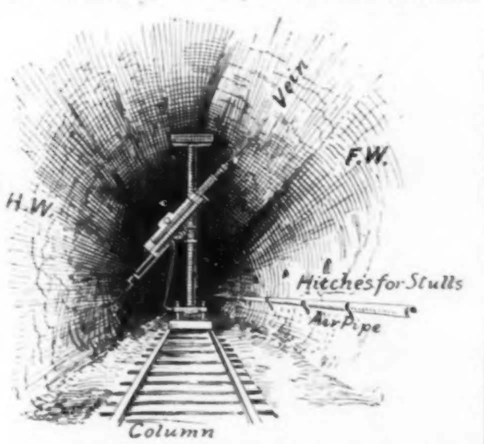


FIG. 4.—INGERSOLL DRILL, PREPARING TO STOPE. COLUMN SET VERTICALLY.

was once a wide open fissure 5 to 10 feet wide gradually filled with ore and quartz, there is no such thing here. Doubtless there was once a crack in the rock, similar to the cleavage planes or joints we have described in the canyon. This fissure or line of weakness, along part of its course, became a zone of alteration and mineralization of the country rock adjacent to it. Thus the so-called vein we see exposed in the roof of the tunnels or on the face of the stopes is in some places simply a line of rusty, rather decomposed rock, but a few inches wide close to the footwall. The remainder of the vein or gangue above the footwall is generally the ordinary gneiss or schist somewhat rusty, with here and there little seams of quartz or feldspar, and narrow streaks of ore, an "impregnation," one would be inclined to say rather than a well defined vein. This mineral impregnation grades gradually into the country rock without any well defined limiting hanging wall. The vein in this part may be described as a zone of mineral impregnation near a line of fracture.

Further on we find this zone occupied by a singular combination, consisting of a belt of "breccia" five or more feet wide, formed of fragments of porphyry and granite. (See Fig. 1.) While most of the fragments are angular, both porphyry and granite often assume a perfectly rounded pebble-like form. Running in

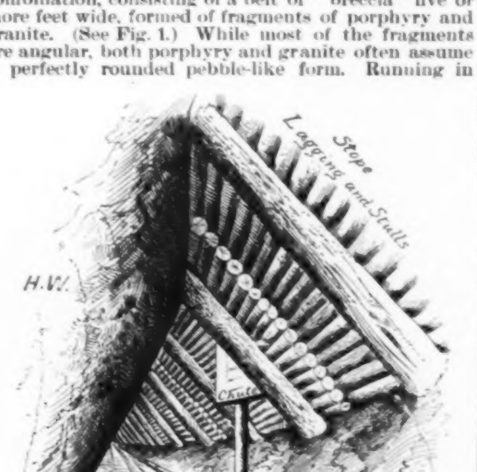


FIG. 5.—METHOD OF TIMBERING A STOPE. DIP OF HANGING WALL, 68°.

and out between these blocks, and often acting as a cement to them, is the ore, mingled with quartzose matter or by itself alone. Sometimes this breccia lies in two well defined zones on either side of a central mass of quartz and feldspar speckled and veined with ore. In most cases the richest smelting ore lies by itself in a narrow zone between the breccia and either the hanging or footwall of gneiss.

This part of the vein doubtless originated in a fissure, which was enlarged by the eruption of the volcanic breccia, which carried up in its embrace fragments of the granite torn from the sides of the fissure, and pieces too of congealed porphyry; and either by alteration, or partial melting, reduced them to rounded pebbles; this may too have been assisted by steam, but it seems hardly possible that underground waters circulating in the fissure could have given the fragments their rounded form.

Such a breccic zone, impregnated with ore matter, may seem anomalous, and different from the orthodox idea of a "fissure vein." It is not, however, uncommon in these mountains, for a porphyry dike without the presence of quartz to be impregnated by mineral and to constitute the vein to all intents and purposes, as for example the vein of the Mattie mine in the same neighborhood, which is only an impregnated porphyry dike.

It is to be observed that a dike of porphyry runs close by back of and parallel to what should be the hanging wall, very nearly making the vein a contact vein, between porphyry and gneiss. (See Figs. 2 and 3.)

In one case toward the end of the third level north, this dike has entered and absorbed the usual zone of the breccia vein, and retained only the narrow zone of the rich smelting ore between it and the gneiss, making this part of the vein a true contact.

This barren porphyry, again in places, cuts through both breccia and vein, and at others intrudes long narrow tongues into the gangue. The vein never passes through this porphyry, but is "thrown" by it. Hence we must conclude that though the porphyry seems of the same nature as that in the breccia, yet it must have been erupted after the breccia, and after the breccia was mineralized.

This porphyry of a light color seems to have been

FIG. 7.—UNDERGROUND VIEW OF A STOPE.

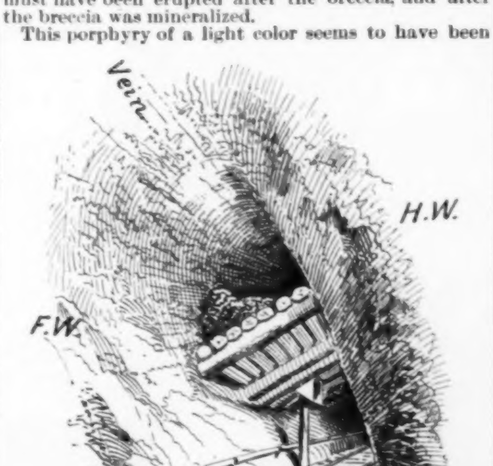


FIG. 6—END VIEW OF A STOPE SHOWING HOW THE WEIGHT OF FALLEN ROCK IS DISTRIBUTED ON FOOTWALL AND LAGGING.

reduced to a highly plastic or even molten condition; for it insinuates itself into every crack and crevice and is constantly and most unexpectedly met with in the mine.

The course of the vein is northeast and southwest dipping to the west at an angle of 68 degrees from the horizontal.

VISIT UNDER GROUND.

We entered the mine by the level, tunnel or drift, different words used for the same thing, close by the roadside on the south bank of the river, known as "Level A" or "the road level." See plan of workings.

This appears to have been one of the early openings into the vein and hill by the old management. For some unknown reason, though but a few feet from the outcropping vein, it was not driven in directly on it, but aimed to cut it by a long diagonal crosscut. This level was 8 feet high by 5 feet wide. It was well and carefully timbered for the first few hundred feet, owing to nearness to the surface making the roof and walls of rock loose and unsafe. The "stulls" or upright timbers as well as the "cap" or top of the arch, were of sawn timbers, cut square, 8 inches thick. They incline inward at a slight angle toward the cap. Back of these the walls were lined with boards, called "lagging." On the floor was the tramway, the rails 18 inches apart, laid on ties as on a railroad.

This diagonal crosscut reached the vein at a distance of 200 feet, when the rock becoming firm and solid, no more timbering was required. The ore of the vein was found, on reaching it, to be somewhat scanty, and lying on the well defined footwall; the hanging wall was less definite. Both walls were of granitic rock. Contrary to the popular idea, two well defined walls, i. e., footwall and hanging wall, are very rare in mines in this region. There is commonly but one wall, and that often but ill defined. The footwall in an inclined vein is that which slopes away from you, and upon which your feet would naturally lean toward, while the hanging wall is the opposite side of the tunnel, where the rock naturally overhangs you or slopes toward you. A wall in a mine is generally recognized by a prevailing smooth surface on one or both sides of the vein. The so-called vein as we have described was

FIG. 8.—DRILL WITH COLUMN USED HORIZONTALLY.

here but a rusty line in the granitic rocks. After 500 feet of this poor material, richer stuff was encountered, which induced them to stope upward. This rich streak or "chute" continued to the "breast" or end of the level for some 1,500 feet, where operations are still continuing.

STOPING.

Stoping is done as follows: An upraise is made by a

power or air drill in the roof of the tunnel to a height of perhaps 50 feet. See Fig. 4, where the air drill pillar is planted in the tunnel and the drill is in the roof. An opening upward is thus made, the dirt from the excavation falling into the tunnel below. From this chute, stoping is commenced; that is, excavating along the vein on either side of this chute, beginning at the bottom. In doing this, the drills are directed in a slanting direction downward so that water can be poured into the holes to assist drilling. In this stope, the gangue matter of the vein is blasted down first, away from the richer streak of ore, which in this mine almost invariably lies close onto either footwall or hanging wall, generally the footwall. Previously, however, so soon as stoping begins, thick stulls are laid across the upper part of the tunnel from wall to wall, each of them 5 feet apart from centers, and on these are laid lagging of poles 15 feet long; forming a floor on top of these stulls. See Fig. 5. The cross stulls in this case were the width of the vein, and 2 feet thick. The butt end of a stull is laid in hitch or square notch, cut in the face of the footwall, and the other end is jammed down on to the head in the hanging wall at a nearly right angle with both walls.

These stulls in this mine, with inclined walls, have to be very thick and strong to support the enormous pressure of the hanging wall, a pressure in this mine increased by the swelling of a body or dike of porphyry behind the hanging wall. So powerful was this pressure that I saw cross stulls 2 feet thick and only 5 feet long, split, broken, bent and crushed at the butts like tow.

The stulls and lagging having been laid as a floor, the work of stoping upward progresses. The dirt falls on the lagging of the floor, but much of its pressure is distributed over the sloping surface of the footwall, instead of all on the floor of lagging and stulls. See Fig. 6.

On top of the dirt that falls from his work upon the lagging floor the miner stands to continue his attack on the vein in the roof of the stope (see Fig. 7 and Fig. 8) with the power drill, whose pillar may be, as in the illustration, Fig. 8, placed across the stope horizontally or else vertically.

After the poorer rock of the gangue (i. e., the vein matter from wall to wall) has been blasted down, and sealed off from the streak of rich ore that in this case lay close to the footwall, the poor, barren rock is broken up small to make a somewhat smooth floor to receive the precious ore as it is broken down. This if soft is either taken down with a pick or gad or else blasted down with a light charge of powder. In Fig. 7 the men appear to be taking the ore off the footwall with hammer and chisel.

Meanwhile, to dispose of this ore and get it down safely into the tunnel below, a chute or mill hole has been kept open and carefully timbered with small cross sets of timber to the level of the floor of the stope (see Fig. 8), where it is as an open chimney down which to throw the ore into the tunnel below, where a car stands (see Fig. 9) ready to receive it and carry it out on the dump, to be wheeled to the mill or sorting room or to the incline shaft for hoisting. As the dirt on the floor of the stope rises, additional cross pieces are added to keep the mill hole or ore chute free and clear from stones. The mill hole is wider at the bottom, which is called a pocket, than at the top. This enlargement is done to prevent stones clogging; hence the mill hole is in the form of an inverted funnel.

Down this ore chute the ore is dumped into the car in the tramway at the bottom of the tunnel.

Very rich ore is sometimes carefully broken down on a blanket spread on the floor of the stope.

The result of driving the drill holes down in a slanting direction is finally to make one end of the stope higher than the other.

FIG. 9.—TRAMMING FROM AN ORE CHUTE.

On reaching near the upper level, if the ore is not very valuable, a pillar is left or else it is stoped clear up to the track and filled in. The vacant space is filled by stoping on one side and filling in, laying cross pieces from wall to wall to support the rails of the upper level while this is in process. Commonly this part is filled up during the night shift, so that by the morning the cars can run on the rails of the upper level.

Mill holes or ore chutes, as they are called, are generally placed at every 40 or 50 feet apart. Men may be working at one end of a stope, and others at the farther end, the drilling holes converging toward the cutter. The cross section of the vein is well seen on the roof and end faces of these stopes.

The gangue is generally a breccia, more or less impregnated with ore, which will pay to concentrate but is not rich enough to smelt. The smelting rich ore keeps close to one or the other of the walls, and is sometimes a solid mass of pyrite or quartz and pyrite.

BLASTING.

Atlas dynamite is used. The power drills of the Ingersoll pattern usually drill in a few hours half a dozen holes 6 or 8 feet deep, according to the amount of rock they desire to break down. A power drill will do in 6 hours what it would take a man by hand labor a week to do. When it is desired to break down a great quantity of rock, a number of holes are drilled at different distances and the charges ignited simultaneously by an electric battery.

The "pillar" mode of supporting the Ingersoll drill in these narrow veins is here preferred to the tripod system. The pillar can be placed in any position horizontally or vertically and they have them of all lengths to suit different widths or heights of the tunnels.

The main air pipe supplying power to the drills passes along the side of the main levels, low down, but above the ground, and is 4 inches in diameter. Smaller inch pipes of iron are attached where side drifts branch off to supply the drills, and to the end of these pipes about 50 feet or more of hose cased in wire is attached as a flexible attachment to the drills themselves. Two men attend upon each drill.

Having duly examined the stope, we proceeded on our way along the main tunnel. At a certain point a crosscut had been made into the footwall, which showed that the vein here had split up into three branches, each of them of fair size and valuable. This shows the importance of occasionally prospecting and cutting into the walls. On one of these veins was a lofty, open, untimbered stope. Here, too, we encountered the porphyry dike which runs back of and parallel with the hanging wall.

We saw places in the tunnel where they contemplated stoping, where the air drill was already in place and about to drill a chute in the roof. The hitches, too, for the butt ends of the stulls were already cut, ready for the carpenters to lay in the stulls. See Fig. 4. It is the carpenter's business to cut the hitches and prepare and set up the stulls and lagging.

(To be continued.)

A WOOD CARVING MACHINE.

A NEW wood carving machine, called the "Eclipse," invented by Messrs. Ryland and Bird, may be seen at work, says the Engineer, by those interested at The Mart, Station Road, Brixton, London. Fig. 1 gives a general idea of its construction and Fig. 2 goes more into details.

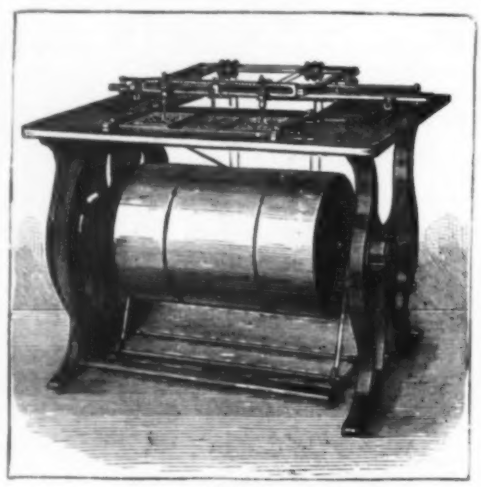


FIG. 1.

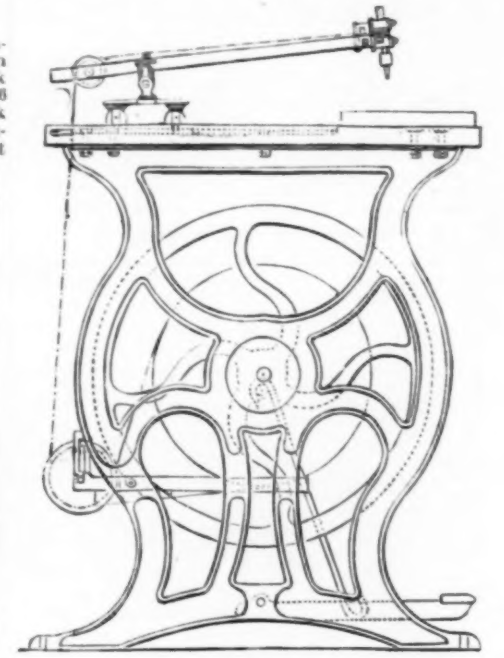


FIG. 2.

A peculiarity of this machine is the elasticity of the motions which can be given to the cutting tool, combined with sufficient rigidity. The tracing pointer and carving tool are mounted on the front portion of a rectangular frame, extending over the machine table; this frame is mounted so that it will rock freely in its bearings; it can be moved in a line parallel to the front of the machine, and to and from the front and back of the machine table.

The back member of the tool frame is in the form of a shaft, on which are freely mounted one or more pairs of guide pulleys for the cutter driving band or bands. In slots or guides at the lower parts of the machine standards is mounted a countershaft, on which are loosely mounted one or more pairs of guide pulleys, and said countershaft is weighted or acted upon by springs to give it a normally downward tendency. The machine frame is fitted with a driving shaft carrying a long drum, and said driving shaft may be driven by a treadle or by power acting upon a driving pulley fixed thereon.

A driving band for each cutter or carving or engraving tool is passed partly around the drum, then partly around the several pairs of guide pulleys above described, and partly around the driving pulley of the carving or engraving tool. The guide pulleys are capable of sliding along their carrying shafts, and the cutter driving band or bands is, or are, capable of traveling along the long drum. By the above construction of parts the tracing point and the carving or engraving cutter or cutters are capable of being moved in any direction over the pattern, and work without in any way affecting the driving of the cutter or cutters.

What with the guide pulleys sliding along their carrying shaft, and the driving bands of the cutters sliding wherever the tension draws them upon the long drum, and what with like freedom of motion of several other parts, the working parts of the machine seem as flexible as India rubber, yet are sufficiently rigid. The machine will cut in any direction, and will undercut to a considerable extent. A boy can work it; indeed has been working it for a few months past. The few of these machines at present made are worked by a treadle. Power carving machines are, however, about to be constructed, also a miniature machine for amateurs. The amount of give and take with this machine, because of its tension gearing, prevents the heating of the bearings of the tools, which are necessarily driven at high velocities, and the length of wood which may be worked with it is unlimited. The machine seems to be able to carve anything, busts included. Various specimens of work done by it are on view, and more can be executed under the eyes of the spectator. The ligaments used with this machine are not leather bands, but cylindrical lengths of catgut, treated occasionally with pure linseed oil gold size, then allowed plenty of time to dry.

A NEW ELECTROLYTIC METHOD OF PRODUCING ALUMINUM.

THE following method, described in a general article on the newer applications of electricity to mining and smelting, by W. Wendelen, has been proposed by the Aluminum Company, of Neuhausen, Switzerland. The material operated upon is aluminum sulphide, which can be readily dissociated by passing an electric current through it when melted, the fusion being effected either by the current itself or an external

source of heat. As compared with other methods, a comparatively low electro-motive force is required to accomplish the reduction, and the carbon electrodes immersed in the bath of molten sulphide are not affected, as the reduction takes place at a temperature below that required for the combination of carbon with sulphur. Short circuiting is also completely prevented, as the reduced aluminum, on account of its higher density, falls to the bottom of the reducing vessel.

As, however, pure aluminum sulphide is difficult to produce, and, consequently, expensive, it may be replaced by a double sulphide of aluminum and some alkali metal, that with sodium, obtained by heating alumina with carbon, sulphur and sodium sulphide according to the following equation :

$$Al_2O_3 + 3C + 3S + 3Na_2S = Na \,.\, 6Al_2S_3 + 2CO,$$

being the most convenient one, as it is readily soluble in a bath of molten alkaline chlorides and flourides. The best material for the bath is a mixture of potassium and sodium chloride kept melted by external heat. When this is used, a low-tension current is sufficient to effect the reduction of the aluminum with almost quantitative exactness and of a high degree of purity. When the fusion is to be effected by heat derived from the current, higher electric energy will, of course, be required, but even then it will rarely be necessary to exceed five volts. The reducing vessel is a cast or wrought iron box lined with carbon, which, like the electrodes, is not injured by the process.

CATHODIC RAYS.

MANY of our readers will doubtless remember the stir that was made about fifteen years ago by the magnificent experiments through which Mr. Crookes, following a path opened up by Hittorf, thought he had demonstrated the existence of a fourth state of matter characterized by the almost absolute liberty of the molecules. All the very ingenious experiments devised by this eminent physicist found in his hypothesis a very natural explanation, which was thereafter generally admitted. Shortly after the first publications of Mr. Crookes, some doubts were expressed by Mr. Goldstein on the subject of his theory, but the memoir of the German scientist passed almost unnoticed, and the idea of the bombardment of molecules remained intact with everybody. Meanwhile, experimenting went on, especially in Germany, where the illustrious and lamented Hertz and Messrs. Wiedemann, Ebert, Jaumann and other savants brought forward in succession numerous arguments against the kinetic theory of the phenomenon. None of these appeared to be absolutely decisive, and it is a recent memoir of Mr. Lenard, a pupil and preparator of Hertz's, that appears to have demonstrated the error into which Crookes had fallen and which was very excusable, since the learned world in general had participated in it, and men such as Lord Kelvin and Sir George Gabriel Stokes had broken more than one lance in its favor.

For a long time now, a goodly number of physicists have no longer been speaking of radiant matter. The phenomena in question are designated by the name of cathodic rays, so as not to implicate any particular theory. This is the name that we shall use in this article for those rays that escape from the cathode after the manner of a projectile, and that were thought to be molecules in motion. The principal phenomenon upon which Crookes' theory was based is that the cathodic rays are produced in tubes in which there is a sufficient degree of vacuum to allow the rectilinear travel of the molecules to become measurable, and yet not perfect enough to prevent the cathode from attracting and repelling the molecules in sufficient quantity to allow the phenomenon to remain visible.

The genesis of the cathodic rays remains surrounded with mystery. The conditions indicated by Mr. Crookes have been merely verified, without, however, a relation of cause and effect having been discovered in the presence of the matter for the production of the cathodic rays. But as an offset, it has been possible to show that the presence of a gas, under a pressure comparable to that of the atmosphere, is not any more than is a perfect vacuum an obstacle to the propagation of these rays. Upon this point Mr. Lenard's experiments are decisive, and they are so important that it is well to describe them in detail.

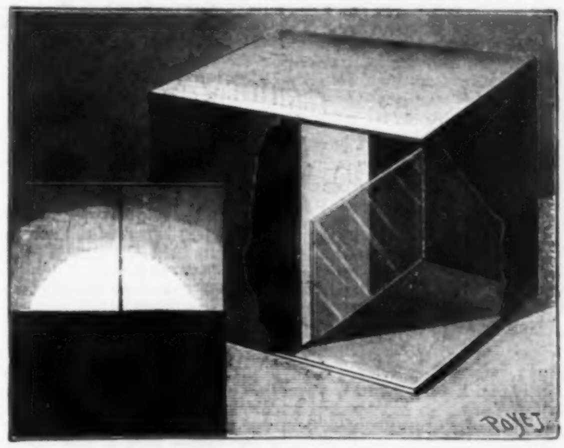


FIG. 2.—ARRANGEMENT OF A SENSITIZED PLATE IN A CLOSED METALLIC BOX.

Hertz showed some years ago that the cathodic rays successively traverse several sheets of metal absolutely impermeable to light, and that they continue to propagate themselves in a straight line in the tube in which they are produced. It is from a modification of this experiment that Mr. Lenard has drawn his best arguments. The apparatus employed for the production of the rays is represented in Fig. 1. The aluminum cathode, C, is placed in the axis of the tube, while the anode, A, is a hollow brass cylinder applied to the sides. A lateral conduit, D, leads to the pump, while the extremity of the tube opposed to the electrodes is closed by a metallic cap, containing in its center a circular aperture, F, 1·7 mm. in diameter, which is covered with a sheet of aluminum about 3 microns in thickness. This sheet suffices to assure an absolutely tight cover, while the rays that have escaped from the cathode traverse it with the greatest facility. After this, nothing is easier than to observe them, either in the air or in an empty tube or one filled with different gases (Fig. 3).

Electric actions ought naturally to be avoided with the greatest care in these experiments, which they might entirely modify. This is why Mr. Lenard takes the precaution to protect the aperture toward the interior by a capsule, V, having a narrow opening, E (Fig. 1, detail in upper right hand corner), while the entire apparatus is surrounded by a metallic screen, G, communicating with the window and with the anode and leading to the ground.

Before describing the experiments through which the existence of the cathodic rays around the aperture is revealed, it is well to refute some objections that might be made to Mr. Lenard's reasoning. In the first place, it might be thought that the aperture itself acted as a cathode and emitted its own rays. But, aside from the fact that these rays would be produced in the air, which is contrary to all preceding

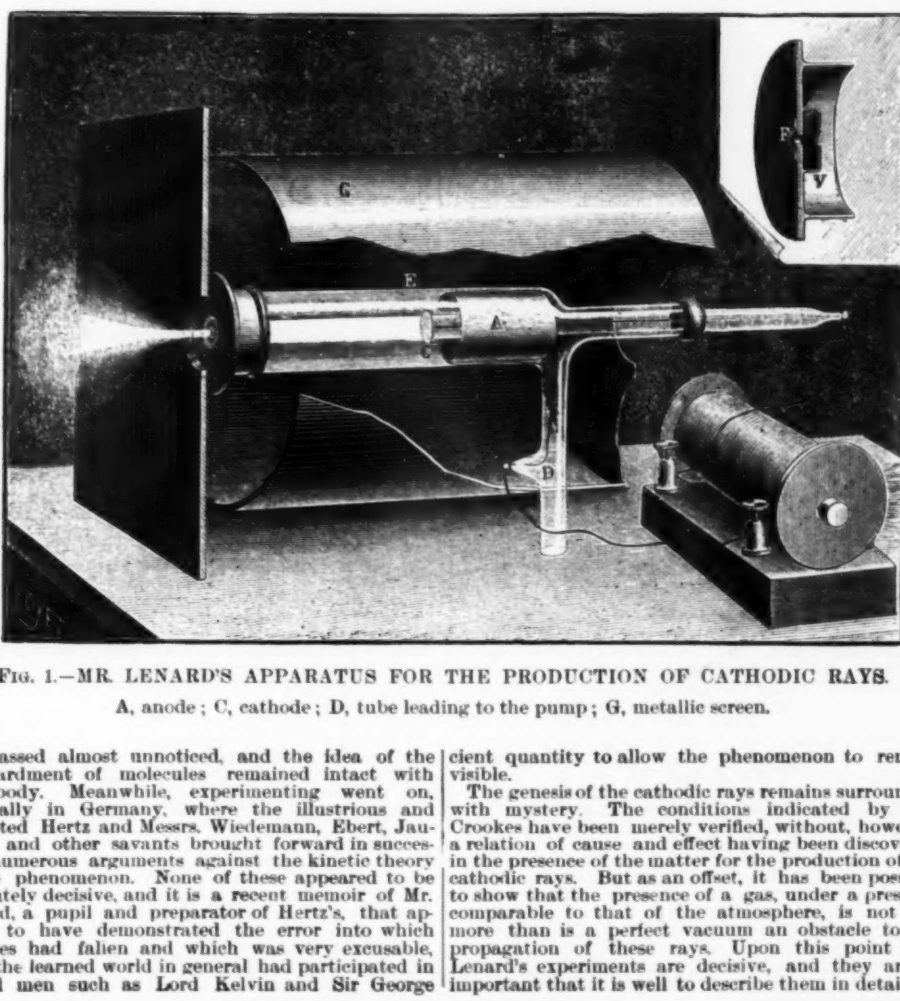


FIG. 1.—MR. LENARD'S APPARATUS FOR THE PRODUCTION OF CATHODIC RAYS.

A, anode ; C, cathode ; D, tube leading to the pump ; G, metallic screen.

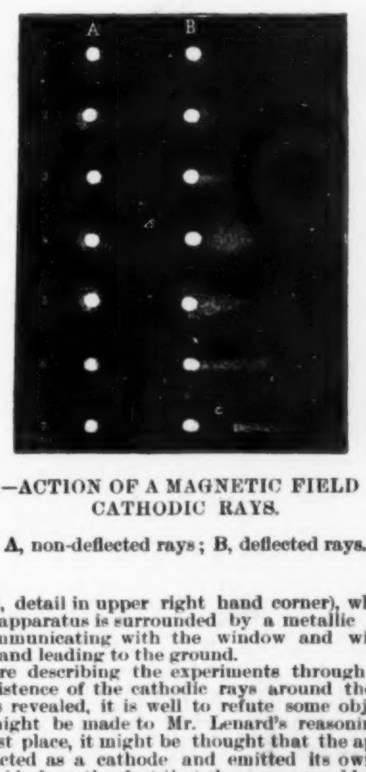


FIG. 5.—ACTION OF A MAGNETIC FIELD UPON CATHODIC RAYS.

A, non-deflected rays ; B, deflected rays.

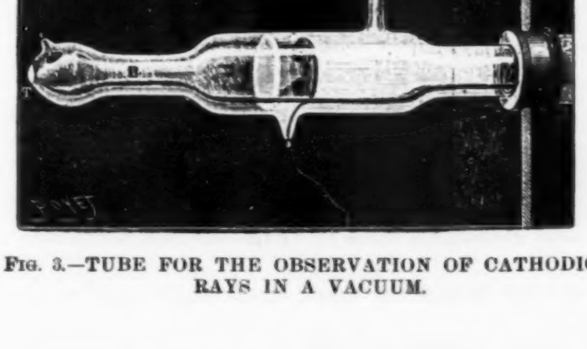


FIG. 3.—TUBE FOR THE OBSERVATION OF CATHODIC RAYS IN A VACUUM.

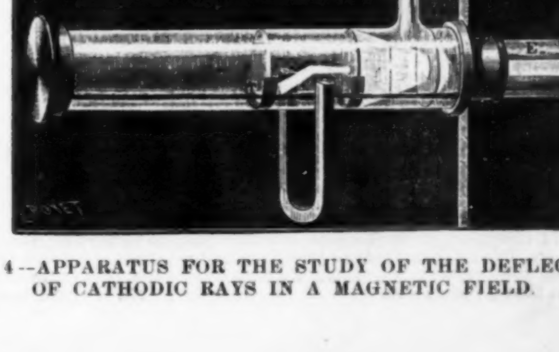


FIG. 4.—APPARATUS FOR THE STUDY OF THE DEFLECTION OF CATHODIC RAYS IN A MAGNETIC FIELD.

experiments, it may be demonstrated that they are entirely independent of ordinary electric forces.

As we shall see further along, the cathodic rays act upon a photographic plate just like light. If we inclose a plate completely in a metallic box of which the anterior side (of but a few microns thickness) is exposed to the cathodic rays, we can obtain an impression just as in the vicinity of the window. Moreover, this latter emits rays only at the places where it is illuminated in the interior, while, if the electric state of the covering were necessary for the transmission of the rays, all the parts in metallic contact with the window would become centers of the emission.

The best method of observing the cathodic rays consists in causing them to fall upon a phosphorescent body. To this effect, Mr. Lenard employs a piece of tissue paper that has been immersed in a solution of pentadecylparatolylcetone, which gives a beautiful green phosphorescence without residua.

It is well to cover the paper at the side at which the rays enter with a thin sheet of metal. The action is but slightly diminished, while the extraneous light is completely arrested. The passage of the rays is very easy to follow by means of this screen, which, in fact, it is possible to place in various positions with respect to the aperture or window and thus obtain different sections of the space containing them. It is then observed that the rays are diffused in the air as if in a disturbed medium, almost as luminous rays enter smoke or an agitated liquid, milk for example. The shadows cast by opaque objects are very indistinct at their edges and the rays strongly encroach upon their geometric shadow.

Solid bodies behave in an entirely unlooked-for manner in the presence of cathodic rays. While their absorbing power for light varies in enormous proportions, they do not seem to present great differences for cathodic rays. We have already said that the latter traverse thin sheets of metal without difficulty. They likewise traverse somewhat thickish paper, but are arrested by carbon. A plate of quartz half a millimeter in thickness absorbs them completely; but it is probable that it would allow them to pass if its thickness were but a few microns. The cathodic rays are not directly visible, and they exert no sensible action upon the skin. They seem to have a peculiar taste, but it is probable that their action upon the tongue is due, like their apparent odor, only to the production of ozone.

These few preliminary remarks having been made, it is well to enter upon the study of the cathodic rays more in detail. The photographic action of these rays is energetic. Not only do they impress photographic plates, but they are even capable of blackening sensitized paper, in the vicinity of the window, with a rapidity comparable to that obtained with a veiled sun. The use of the photographic method permits of determining the transparency of bodies for such rays with more precision than does the phosphorescent process. The following experiment is very instructive. A sensitized plate having been covered (as shown in Fig. 2) at its lower part with a plate of quartz half a millimeter in thickness, and upon the right half with an absolutely opaque sheet of aluminum, we obtain as a positive the result represented to the left of the figure. It will be seen that the sheet of aluminum has given only a slightly visible shadow, while the plate of quartz has almost completely intercepted the action of the rays. The very feeble attack of the portion of the plate covered only by the quartz is due, not to the rays, but to the phosphorescent light emitted by the air. The quarter of this light protected by the sheet of aluminum and kept from the action of the rays by the plate of quartz does not, in fact, show the least trace of decomposition.

Another experiment, in which the photographic plate had been covered with a sheet of cardboard 0·3 millimeter in thickness, showed that this sheet was relatively quite transparent, while the experiments with the phosphorescent screen did not permit of ascertaining it. It became manifest, however, upon interposing a few strips of thin metal between the cardboard and the photographic plate, that the action was due to the cathodic rays, and not to the ordinary light. Photographic actions are the only chemical ones that Mr. Lenard has observed.

Electrified bodies rapidly lose their charge under the influence of the cathodic rays, and the latter, on the contrary, communicate no charge to the conductor. A Faraday cage or a thin sheet of metal in nowise prevents the action, which is still very sensible at 30 centimeters from the window. On the contrary, a plate of quartz placed upon the window arrests the phenomenon.

The experiments that we have just described already demonstrate the inadequacy of the hypothesis of molecular bombardment to explain the phenomena due to the cathodic rays. Other researches of Mr. Lenard's will aid us in getting a glimpse of their true theory. We said in the beginning that these rays are observed in a vacuum with the greatest facility. It suffices for this to apply against the window a glass tube, B (Fig. 3), emptied as well as the best mercurial pumps permit. Electrodes placed in this tube serve to make sure whether or not it is improper for the production of the rays. When the two tubes are put in communication, it is possible to produce the rays indifferently in either. When the first tube is actuated, we see the sides of the second become illuminated in the vicinity of the window, and, as the electrode is provided with a central aperture, we perceive a luminous spot, T, at the other extremity of the tube, while the gas that it contains exhibits a feeble phosphorescence. If, now, we continue to empty the tube of observation alone, we shall see the rays becoming feebler and feebler therein and soon disappear when we try to produce them in the tube, while the phosphorescence becomes clearer therein when the rays emanate from the tube, E. The experiment may be carried on for hours without the tube, B, becoming proper for the production of the rays. There is then no carriage of matter from E to B.

All these experiments establish, in a manner that seems irrefutable, the fact stated in the beginning, viz., that the cathodic rays are propagated without the direct intervention of ponderable matter. The phenomena are, like light, influenced by the presence of matter, but they exist aside from it in the imponderable medium that we call ether.

We have seen that the air acts upon these rays in the manner of a disturbed medium. It became of interest, from this point of view, to examine various gases under different pressures. When illuminating gas is made to flow in front of the window, we observe an increase in the transparency of the medium; but it is possible to perform the experiment under better conditions. To this effect, Mr. Lenard applies against the window a cylindrical tube 1·5 meters in length that may be filled with different gases. The phosphorescent screen, which is covered with a sheet of aluminum 13 microns in thickness, is mounted upon an iron foot that permits of displacing it by means of a magnet. A strip of mica applied against the aluminum is designed for throwing a shadow upon the screen. The process of examining the medium consists in seeking the position in which the screen begins to become luminous around the mica. The phosphorescence may be produced at several meters distance from the window or aperture under the feeblest pressures, and it is in order to effect the extinction in the tube that the screen was covered with a relatively thick layer of metal.

On introducing different gases successively into the tube, it is found that their absorbing power increases regularly with their density, from hydrogen, which is the most transparent, to sulphurous acid, which is the most opaque of the gases examined.

When the tube is provided, not far from the window, with a diaphragm having a circular aperture, an image of the latter, surrounded by a more or less intense halo, is perceived upon the screen (Fig. 5, No. 1. A). The sharp part of the image corresponds exactly to the geometrical projection of the free space of the diaphragm, while the halo is due to the diffusion of the rays in the gas filling the tube. The phenomenon is identical with that which is observed when we look at an illuminated disk through a vessel with plane sides into which water mixed with a little milk has been put. Upon diminishing the pressure of the gas or replacing it by another of less density, we see the image increasing in distinctness, while the halo becomes less and less intense. The aspect of the halo permits of characterizing the diffusion of the rays by the gases that they traverse. Upon operating in various media, and under very variable pressures, Mr. Lenard has succeeded in arranging these gaseous media by order of transparency. Now he finds that such order is precisely the opposite of that of densities, without, however, the nature of the gas intervening in any way; whence, for gases, we deduce the very simple law that the action upon cathodic rays of the same nature depends only upon the masses traversed.

But such rays are not all identical, for they differ according to the conditions of their production, and it is observed that they propagate themselves so much the more easily in proportion as the tube in which they are produced is more completely emptied. They correspond to radiations of different lengths of waves, and if they are due to an undulatory phenomenon, it appears evident that the period is so much the shorter in proportion as the pressure under which they are engendered is stronger.

We have seen that the cathodic rays are very probably due to a motion of the ether. If it is true that gases act upon them simply like a disturbed medium, we conclude, therefrom, by analogy with optical phenomena, that the molecular dimensions are not negligible with respect to their wave length.

We have known for a long time that the cathodic rays become so in a magnetic field. This phenomenon, which is in perfect accord with the theory of Mr. Crookes and the ideas of Faraday, had given a solid support to the hypothesis of bombardment.

A very simple reasoning, however, led Hertz to express some doubts as to the legitimacy of this explanation. If the magnet exerts a mechanical action upon molecules in motion, there should be a reciprocity. Now, we observe no action of the cathodic rays upon the magnet. We can, however, always attribute a negative result to a want of sensitiveness, and it is for this reason that the experiment of Hertz does not appear conclusive.

The phenomenon of which we speak may, nevertheless, furnish a new argument for the theory of the German physicists. In the Crookes hypothesis the deviation of the rays should evidently depend upon the nature and density of the gas to the movement of which they are attributed. Now, by means of the apparatus shown in Fig. 4, Mr. Lenard has performed some comparative experiments upon the air and hydrogen under pressures starting from 0·02 mm. and reaching respectively 31 and 332 mm. for these two gases. As in the preceding experiments, the rays are produced in the tube, E. They first traverse a very wide diaphragm, and then another one provided with a narrow aperture. These rays are deflected in passing between the branches of the magnet and form upon the screen the spot, T, whose position is determined by means of a scale. The deflections show no systematic travel, and thus appear to be, within wide limits, independent of the gaseous medium in which they are produced.

It will be remembered that the cathodic rays differ as regards the greater or less ease with which they traverse a disturbed medium. They exhibit analogous differences in their refrangibility in the crossing of a magnetic field.

In most cases the image of the diaphragm deflected by the magnet (Fig. 5, series B) is similar to the non-deflected image. The distinct part is in the center of the halo, but sometimes it is eccentric, and in this case the halo is always more deflected than the spot. Sometimes, even, the latter is completely detached from the central spot. In a greatly rarefied gas in which no halo is observed, the latter becomes apparent as soon as the rays are deflected (Fig. 5, Nos. 6 and 7). It is no longer then due to diffusion, but solely to the stronger action that certain of these rays experience on the part of the magnetic field.

Upon comparing this phenomenon with a result already enunciated, we shall not find it difficult to conclude that the cathodic rays are so much the more refrangible in proportion as their wave length is shorter.

This analogy with luminous phenomena cannot fail to be very suggestive. We get a glimpse of the study of the spectrum of the cathodic rays, whose magnetic field is the prism.

Mr. Crookes' theory, as plausible as it has hitherto appeared, seems at present entirely inadequate. We find ourselves in the presence of a new domain, which has been but little explored, and which has many surprises in store for us. We already know to what the cathodic rays are not due, and it is Mr. Lenard's great merit to have given a demonstration of it. What is their intimate nature? What is the mysterious role of matter in their genesis? Such are the questions that are now proposed, and that physicists will, perhaps, be able to answer with more probability after experience shall have more completely enlightened us.—C. E. Guillaume, in La Nature.

[FROM THE POPULAR SCIENCE MONTHLY.]

SKETCH OF HEINRICH HERTZ.

By HELENE BONFORT.

WHEREVER the investigating minds of scientists are at work promoting the insight of man into the mysteries of nature, wherever friends of natural philosophy are keenly alive to the importance of this comparatively new field of study, a field in which lie some of the most essential interests of modern civilization, there will be sincere and deep regret over the death of a young professor whose splendid career came to an untimely end on the first day of this year. Prof. Heinrich Hertz, of the University of Bonn, in Germany, died on January 1, 1894, not yet thirty-seven years of age. For the last two years he had not been in good health, and, though under the treatment of his capable physicians he several times rallied and seemed to be restored to his former strength, the last winter brought a serious relapse. A chronic and painful disease of the nose spread to the neighboring Highmore's cavity and gradually led to blood poisoning. He was conscious and in possession of his full mental power to the last; he must have been aware that recovery was hopeless, but not a word escaped his lips that would have shown to his dear ones whether hope or fear filled his heart. His wife and his mother were at his bedside for many weeks, giving him their tenderest care, and, in spite of his continuous sufferings, there were many hours of genial discourse. At such times they read to him, and he gave himself up to general topics and to matters of personal interest to them, displaying even yet his wonted brightness and cheerfulness.

Heinrich Hertz, born in Hamburg on February 22, 1857, was the eldest son of exceptionally good and clever parents. His father was, at the beginning of his career, a lawyer; in due course of time he rose to the position of judge of the Supreme Court of Appeal, and has now been for a number of years a senator of the free city of Hamburg. The childhood of Prof. Hertz was subject to every pure, healthful, and elevated influence that a highly capable father and a superior mother can exercise. Both of them gave a great part of their time to their children; their eldest boy especially enjoyed the advantage of their companionship in many a holiday's ramble through the green fields and woods, and in cozy winter nights spent in reading Homer, the German classics, and other books.

In passing through the high school classes of his native city, his predilection for the study of natural science early asserted itself. Whenever a new course of study began and a new textbook was put into the hands of the class, the boy would devote every leisure moment to the perusal of the volume, experimenting frequently with apparatus made by himself, and never ceasing until he could tell his father, "I have mastered that book." This statement always proved to be perfectly correct. In spite of his decided gift for natural science, Hertz chose as his vocation civil engineering. But when, after completing his studies, he came to take the first steps toward the practical execution of this design, he felt that his choice had been a mistake. His parents, with a ready perception of the deeply rooted needs of his strong and peculiar nature, whose desires they would not think of thwarting, entered into his new idea, gave him their approval, and furnished him with the necessary means. So he set out on a new course of studies in mathematics and natural science. He gave himself up to this work heart and soul, and for a number of years knew no other object in life but unceasing and unrelenting hard work. He studied physics at Munich and Berlin, and enjoyed the warm regard of Prof. Helmholtz. In 1880 he became his assistant, and, at his instigation, in 1883, settled down as a "Privat-docent," or professor without salary, at the University of Kiel. It was from this time on that he made the science of electricity the one great object of his researches, the main pursuit of his life. The first years were filled with investigations relating to electric discharges, etc. He busied himself, above all, with the new conceptions of the inner mechanism of electric phenomena, and of the connection between these and the phenomena of light and of radiant heat. These conceptions, originating with Faraday and Maxwell in England and represented in Germany by Helmholtz, were now carried forward by Prof. Hertz.

His reputation soon spread through his native country and he was in 1885 called to the Polytechnic School of Karlsruhe, which for various reasons became very dear to him. One of its attractions was the exceptionally fine and well endowed laboratory of the institution, which furnished the most desirable facilities for unlimited experimenting. At Karlsruhe Prof. Hertz found a wife who was in every way a lovely and graceful, devoted and highly intellectual companion to him. His life was from this time on divided between the pursuit of his main object, the progress of science, and home happiness; both he and his wife derived rare gratification from literature and the beauty of nature. It was from Karlsruhe that he went to Heidelberg, there to enjoy the proudest moment of his life, in the year 1889, when, greeted with enthusiastic applause by most prominent scientists, he stood up on the platform to tender an account of his researches and their results. Who that saw him there, the very picture of youthful vigor and life, could have foreboded that those fine and penetrating eyes, to which for the first time since our earth turned around its poles electric waves had been revealed, were so soon to be closed in death!

Soon Prof. Hertz received flattering calls to the most prominent universities; he preferred the smaller town of Bonn, where he settled down in 1890, even to Berlin, the capital, because what he sought after was the most

serious and fruitful work, not glory and outward advantage. In Bonn he succeeded to the eminent physicist, Prof. Clausius; this was in itself a high distinction conferred upon so young a man as Prof. Hertz. Considered all over Europe as one of the most prominent, he was looked up to as one of the most promising leaders in the science of electricity. Not only had his own country conferred high honors upon this young and ardent worker, but the chief academies of England, France, Italy, Austria and Russia now crowned his efforts with prizes, honorary memberships and other tokens of universal esteem and gratitude.

Up to the middle of this century the phenomena of electricity and magnetism had been only inadequately explained by applying to them Newton's law of gravitation and asserting that, in the same way as celestial bodies exercise power of attraction at a distance and without the intervention of a medium, the two kinds of material electricity were attracting and repelling each other, while passing through space or through nonconductors.

It was the great English physicist Faraday who first sought to carry the knowledge of electricity to a higher stage, by entering upon the study of phenomena with a mind free from preconceived opinions. He put forth as the foundation on which to base new theories his observations of electric and magnetic forces, their influence upon each other, their attractions for material bodies and their propagation by the transmission of the excitation from one point of space to another. He questioned the assumption of space being void, and conjectured that the ether which transmits the luminous waves suffers modifications perceived under the form of electrical and magnetic manifestations. His discoveries, important as they were, gained due consideration only when Faraday's great countryman, Maxwell, treated the same subject in a purely scientific and theoretical way, publishing in 1865 his Mathematical Theory of Light. The nature and properties of ether he left undecided, and they form to this day dominant questions, destined, it seems, ultimately to reveal the deepest secrets of natural science. Maxwell labored to confirm the connection, surmised by Faraday, between light, electricity and magnetism; the idea of velocity now entered the theory and became of supreme importance. Maxwell arrived at the conclusion that the velocity of electromotion in a given medium must be identical with the velocity of light in the same medium, and that, therefore, ether, being contained in all ponderable bodies, would have to be looked upon as the conductor of electric motion and power. Consequently the periodical motions of ether, which our eye conceives as light, and which he figured as transversal waves, were considered by Maxwell to be at the same time undulations of electricity. These conceptions, unproved by experiment as Maxwell left them, had merely the value of a scientific hypothesis emanating from a man of rare genius. To have proved them facts, and thereby to have united two vast and highly important domains of natural philosophy, is the lasting credit of Prof. Hertz.

The complexity of phenomena of light and electricity and the insufficient opportunities afforded by the laboratory for deductions of such magnitude rendered the obstacles barring the road to exact observation well-nigh insurmountable. Many of the best and ablest naturalists were laboring to cope with these difficulties. Two English scientists of highest standing, Prof. G. F. Fitzgerald and Dr. O. T. Lodge, were during the eighties occupied with experiments for the investigation and measurement of electric waves. But it was reserved for Hertz to discover and apply with marvelous ingenuity the necessary "detector," a resonating circuit with an air gap, the resistance of which is broken down by well-timed impulses, so that visible sparks are produced. After an unceasing course of experiments, in which he manifested indefatigable energy and a wonderful faculty of reaching the very essence of the matter, he succeeded in deciding the questions: Is the propagation of electrical and magnetic forces instantaneous? and further: Can electrical or magnetic effects be obtained directly from light? The paper on Very Rapid Electric Oscillations, which was published in 1887, was the first of a splendid series of researches which appeared in Wiedemann's Annalen between the years 1887 and 1890, and in which Hertz showed with ample experimental proof and illustration that electro-magnetic actions are propagated with finite velocity through space. These twelve epoch-making papers were afterward republished—with an introductory chapter of singular interest and value, and a reprint of some observations on electric discharges made by Von Bezold in 1870 under the title "Untersuchungen uber die Ausbreitung der elektrischen Kraft." A translation of this book, entitled "Electric Waves," by D. E. Jones, B.Sc., with illustrations and a preface by Lord Kelvin, has just been published in England.

In 1889, when laying before the Congress of German Naturalists at Heidelberg the results of his labors, Prof. Hertz, with the modesty characteristic of the true investigator, the utterly unassuming disciple of science, gave ready and graceful acknowledgment to the efforts made by his predecessors or co-operators in the work, some of whom had all but attained the results which they aimed at and which he achieved. It is pleasant to recollect that when he had gained the end toward which they also had been striving, the English professors, Oliver Lodge and Fitzgerald, were foremost in announcing his success, and in preparing the English-speaking world to appreciate the importance of his discoveries. A natural bent of mind toward the questions at issue had awakened the young professor's creative powers; his complete concentration upon the vital point and his intuitive perceptions led him to definite results and complete success where so many able minds had searched in vain. In the April number of this magazine Herbert Spencer, speaking of the late Prof. Tyndall, gives a number of traits that apply with singular force and exactness to Prof. Hertz. Of these the first is "the scientific use of the imagination." It may well be said that with this constructive imagination, as Mr. Spencer terms it, originated Prof. Hertz's rare success as a discoverer and as an instructor.

To find out the most effective arrangement of electrical conductors and to secure the conditions which would produce the strongest vibrations at regular intervals and in quickest succession, we might say the adjustment of his instruments was the first part of his work. Having brought about electric undulations up to several hundred millions in one second, Hertz proved through experiment that the waves of electricity are transversal like those of light, and that the transmission requires a certain lapse of time. He ascertained exactly the velocity of electricity; it is found by multiplying the length of wave, which he measured, by the duration of the vibration, which can be calculated, and he found this velocity to be, as Maxwell had supposed, equal to that of light, and, moreover, equal to the velocity of electric waves in metallic wires. The grand consequence of this last discovery was the cognizance of a new fact; that what had hitherto been considered as a current of electricity in a wire is really a movement along the surface of the wire. Maxwell's magnetic theory of light found further corroboration by the experimental demonstration of electric power as propagating from its center in waves similar to sound. The electric undulations are subject to the same process of reflection, refraction, absorption, etc., as the rays and waves of light, from which they are in the end distinguished only by their considerably greater length, measured sometimes by kilometers. The crowning experiments of this course finally changed what had hitherto been looked upon as a coincidence between two orders of distinct phenomena into a demonstration of identity. By gathering the electric spark in the focus of a large concave mirror, whence it came forth in the form of a rectilinear beam, the properties of the electric ray were shown to be identical with those of a luminous ray, the former producing phenomena which have heretofore been observed only in light—those of polarization. This result renders all theorizing on the matter superfluous; the identity of the two powers springs from the experiment itself; ocular proof is produced for the proposition that light is in its very essence an electrical phenomenon, whether it be the light of the sun, of a candle, or of a glowworm. Suppress electricity in the universe—light would disappear. Suppress the luminiferous ether—electric and magnetic forces would

HEINRICH HERTZ.

cease to act through space. Even a body not casting light can be a center of electrical action if it radiates heat. Electricity therefore possesses all nature and even man. The eye itself is, in fact, an electrical organ.

The influence of this new system of physics upon the development of natural science and the manifold applications in practical life of which it is capable cannot easily be overrated. Only recently a new application of Hertz's discovery was made by an American, who is trying to develop photographs by the agency of the Hertzian waves, as science has named them—that is, by electricity instead of light. Hertzian waves, Hertzian investigations, apparatus, and methods form henceforth an essential part of all hand and text books of electricity. The facts established by Hertz's experiments have been moulded into a mathematical formula by their author, who in this purely theoretical work also has shown himself to be a master of high genius in the realm of abstract science. There is at present in press and will soon be issued by T. A. Barth, at Leipsic, a comprehensive work, "Principles of Mechanics in a New Connection," found among his unpublished papers at the death of Prof. Hertz. Its appearance is eagerly watched for by the scientific world.

However highly his own time and posterity may prize the man of science, the great discoverer, in Prof. Hertz, his value as such to the world at large does not surpass that of the rare purity and greatness of his character, of the intrinsic merit which he possessed for those who knew him personally. A world-wide reputation so rapidly attained might have produced in the young man some feeling of elation and pride, and in his colleagues somewhat of envy. But as Prof. Hubert Ludwig, representing the University of Bonn at Prof. Hertz's funeral in Hamburg, said in his memorial speech:

"The rich harvest of fame and glory which was granted him, and that was so fully merited as not to be tainted by a single breath of envy or jealousy, never caused him to give up one atom of the noble simplicity and genuine modesty which were a fundamental trait of his character. His modesty was a most lovable quality in this great man, asserting itself not only in everyday life, but also in his scientific labors, which it pervades with the endearing charm of an amiable personality. It was coupled with the most considerate indulgence when judging others. His ever-ready recognition of other people's merits made it a sheer impossibility to grudge him his attainments or to be his enemy.

'None knew him but to love him,
None named him but to praise.'

At the same time he was governed by an inflexible veracity."

He was indeed a most lovable man, and was never happier than in giving pleasure to others. His kindness and benevolence found expression in many ways, most of all toward those above whom he was placed as head of his department in the university. It was a pleasure to notice his satisfaction, when he found it in accordance with his duty, to confer a benefit or favor. And when it was incumbent upon him to refuse or displease, he became the director who performed his duty, and the friend who regretted what had to be done. He was always ready to show hospitality to scientific men who came to Bonn from other parts of Germany or from foreign countries. Even under the restraint of a foreign tongue (he spoke English and French with considerable fluency) his conversation was charming. Not what he had achieved gave him his ascendency in scientific discourse, but what he beyond a thousand learned men could achieve at any time—original and sagacious thoughts, springing up on the spur of the moment, and losing none of their force by being expressed in the most unpretending, simple form. When entertaining friends or conversing with his dear ones, he perfectly forgot the learned professor in himself; he was so much at his ease, so full of fun, that none around him could help sharing his gayety. Many of his guests, prominent men of science as well as students, will always remember with pleasure and gratitude delightful trips made with Prof. Hertz to the Siebengebirge or evenings of genial intercourse at his house in the Quantiusstrasse at Bonn. Absolutely devoid of any desire to pose before the public, the professor sometimes astonished students newly entered for his lectures by putting in a bit of humor where they had expected abstract instruction; but they soon found themselves none the worse for it. Some simple word, a casual remark made as if it were a self-understood thing, from his lips did more toward improving the mind of his audience than a long lecture from another. He was not a scientist inculcating one special branch of knowledge—he was a thinker. To be considered an authority, even by the youngest beginner, was an idea that never entered his mind. In the congenial atmosphere of advanced classes, new ideas and conceptions seemed to rise in him and flow from his lips as though there could be no easier thing in the world. He was at his very best when propounding a problem to this small circle, showing how he would attack it. None, however capable, but could profit by this teaching; genius itself seemed to prompt it.

With penetrating perspicacity he took hold of his problems. As a veritable disciple of natural science, he strove to accomplish his ideal ends, although by means of theory, which he completely mastered, yet not merely by theory and not for her sake only; what he aimed at first and last was the most accurate establishment of facts. Pervaded as his strong personality was by an absorbing love of his science, the rare harmony of his nature kept him equally from an exaggerated enthusiasm and from prosaic dullness. An uncommonly great number of valuable researches made at the Physical Institute at Bonn during the short time of his leadership prove his rare capacity and untiring eagerness to incite young talents to the best possible application of their faculties and so pave the way for their success in research. But in a wider sense of the word we may call his disciples all those physicists who are at this moment, and will be for a long time, occupied in exploring the provinces which he was the first to open. In this sense almost one quarter of all living physicists call themselves Prof. Hertz's followers.

The honors paid at his funeral to the memory of this young and ardent worker were exceptionally great. He was buried in his native city, Hamburg, where the most widespread sympathy for his family and the deepest regret over his loss were shown. From Bonn, Karlsruhe and Berlin came friends, colleagues and students, some of them officially representing their colleges. Universities and prominent men from all parts of our globe have sent messages of esteem and sympathy to the wife, the parents, and the University of Bonn. It may be questioned whether such utterances of sympathy and respect, much as they tend to make mankind feel itself as one, can offer consolation to those whose bereavement is greater than words are able to convey. However, what Mr. Lowell said in one of his simple and admirable memorial addresses is certainly true:

"It may seem a paradox, but the only alleviation of such grief is a sense of the greatness and costliness of the sacrifice that gave birth to it, and this sense is brought home to us by the measure in which others appreciate our loss."

Prof. Hubert Ludwig, of Bonn, uttered the last farewell at the grave of his friend and colleague. He expressed the sentiment of those grieving at his bier in these final words:

"This loss is so great that we are tempted to recall the old saying of the envy of the gods. But in this solemn hour let us resolutely banish such temptation, and instead of rebelling against destiny, let us at the open grave of this God-inspired investigator bow low our heads and hearts before the inscrutable."

NEW RESEARCHES ON THE INFRA-RED REGION OF THE SOLAR SPECTRUM.

By Prof. LANGLEY.

IN September, 1882, I submitted to the Academy a communication entitled "Observations on the Solar Spectrum," accompanied by a figure of the curve of energy of the infra-red spectrum obtained by means of a glass prism. On referring to this curve we see that below the wave length 1·2 μ we have obtained only twelve inflections, great and small, including the great

band, the wave length of which is about 1·8 μ, the band which I have since designated as Ω, the existence of which has been established with precision by the observations made at Mount Whitney. It will be remembered that the existence of heat has also been established at a distance of nearly 3 μ, the limit at which the prism ceased to transmit the radiation.

Photography has not succeeded in representing a much larger part of the infra-red than the eye has been able perceive, considering that the rays whose wave length exceeds 0·8 μ can be distinguished with the naked eye, and I do not know that photographs have been published giving radiations the length of which is much above 1 μ.

Certain interesting results have been obtained even below this point (1 μ) by procedures of phosphorescence. But, if I am not mistaken, the curve given in my communication to the Academy comprised our principal actual knowledge concerning the extreme region, around and beyond Ω in the spectrum of a glass prism. These inflections were obtained and determined by means of the bolometer, and by a procedure so slow as to leave us no prospect of carrying our measurements much further.

In 1890 the Congress at Washington authorized certain astrophysical researches, the execution of which was intrusted to the Smithsonian Institution. Thanks to the experiments conducted in the last years, we have at last succeeded in substituting for the slow and personal method just referred to, another, which—though founded on the use of the bolometer—is almost automatic, and which, while much superior to the old method in precision, is at the same time incomparably more rapid and delicate.

The bolometer and its appendages have been improved in such a manner that they are not confined to indicating a change of temperature; they also give its value where its variations are below one-millionth of a degree C., since they are shown in the metallic ribbon of the bolometer, which has $\frac{1}{20}$ mm. in diameter and $\frac{1}{500}$ mm. in thickness.

Clockwork of great precision moves the spectrum in such a manner that each of the rays, visible or invisible, passes successively over the ribbon, which meantime, on account of its slight mass, changes its thermic equilibrium in so short a time that it may be regarded as insensible. Since what is dark to the eye is cold to the bolometer, the presence of an invisible absorption ray is indicated by an almost instantaneous deflection of the galvanometer.

This deflection was formerly shown to the eye upon a scale. At present there is substituted for the scale a sensitive photographic plate, moved in a vertical direction by the same perfect wheelwork which passes the spectrum over the bolometer. It follows that the curve of energy is registered in a perfectly automatic manner by means of photography, with the aid of the bolometer, in regions hitherto quite inaccessible to photography alone.

A perfect synchronism being thus secured in the movement of the photographic plate and of the distant circle which carries the prism, we see without difficulty that the curve traced automatically can show us at first sight not merely the magnitude of the variations of the temperature of the spectrum, but also the exact part of the spectrum where they are produced.

Not many dozens, but thousands of deflections, corresponding to the Fraunhofer rays of the visible spectrum, may thus be registered; and we can now obtain with precision, in an hour, results which could not be obtained with the micrometer even at the cost of many years of arduous work, so well that we may take for comparison in one and the same day several representations of the entire spectrum. These, as well as others obtained on different days, are submitted to a strict comparison by a method which checks the existence of each inflection, at the same point of all the curves thus traced independently of each other, with a probable error of position which corresponds to less than a second of an arc. On thus examining the lower invisible spectrum, we discover that it is the seat of absorption, at least as complex as those produced in the visible spectrum, and the new method already distinguishes more than 2,000 invisible rays. The maps of this region, hitherto unknown, will soon be published.

To prove to what extent the new method possesses the power of separation, we may apply it not only to the invisible spectrum, where for the present our word must be taken for the results obtained, but to the visible spectrum, where it may be applied to the study of a known region, e. g., that of the ray, D. Our apparatus, purely thermometric, not merely resolves this ray into its two elements, but reveals the ray of nickel found in the middle. This is the well-known test of visual spectroscopes of considerable power.

The graphic trace, on the contrary, is automatic and of a double effect. We have first the curve of energy obtained automatically; the abrupt inflections are due to the extreme sensitiveness of the apparatus. It registers photographically the variation of temperature produced by each of the rays, which separately are invisible unless magnified.

A method, the details of which will be given in a future communication, renders it possible to convert this curve of energy into a linear spectrum. This linear spectrum, which the author gives in his memoir, is obtained by an automatic procedure applicable to all parts of the spectrum. Although the known angular distance between the rays, D, in the spectrum given by rock salt, scarcely exceeds ten seconds of the arc, the ray of nickel appears so separate from its neighbors that the possibility of a much further resolution appears evident. The instrument can separate rays whose interval does not exceed two seconds. Now, since this purely thermometric process is applicable in the total extent of the invisible heat spectrum given by a prism of rock salt on a surface of 2° (say 7,200″), we may say that this procedure has a power of resolution capable of revealing to us thousands of rays, if they exist.

Taking the instance of these D rays, my object has been to inspire confidence in the assertion that the entire inferior infra-red spectrum, from 1·2 μ to 6 μ, may now be reproduced automatically by a process giving hundreds of rays for each ray known hitherto, and that the relative position of each will be given with a precision hitherto unknown for measurements of this kind.

Let us add that not merely the greater part of the solar energy is found in this little-known region, but the absorptions seem to be due to our atmosphere rather than to that of the sun. Hence it is not improbable that their study may supply a precious means for foreseeing the variations which influence meteorological perturbations.—Comptes Rendus, cxix., p. 388.

PHOTOMETRY.*

By Capt. W. de W. Abney, C.B., F.R.S.

LECTURE I.

The lectures on photometry are not given with the idea that they will be of practical value for the measurement of gas light. There is excellent literature on the subject, part of which I shall have to refer to during my course. What I have undertaken in these lectures is to endeavor to give an idea of the general principles of photometry, almost restricting myself to the scientific aspect of the question. Photometry, in its broadest sense, is the measurement of light, at least so we must think, from its derivation. Now, the light measured may be light coming from an object, or from a self-luminous body, such as a candle or the sun, or it may be the light transmitted through objects. In the second case, if an appropriate screen be used to receive the light, we are in reality measuring the illuminating power of the source of light, rather than of the light itself. Hence, almost as much depends upon the screen on which the light is received as on the light itself. A screen is usually what is called white, and by white is meant a screen which reflects every color equally well; but I would remark that in London the white may become imperceptibly brown, and such color may interfere materially with accurate results. But the photometry that I am alluding to not only includes the measurement of the illuminating power of light, but the measurement of the light transmitted through bodies of various kinds, when they are transparent, like plain glass, or translucent, like ground glass or paper. The requirements of the candle power of gas I shall not enter into, as it is a subject which others than myself are much better fitted to deal with.

We may take it, I think, that the first matter we have to consider is the light we have to use as a standard. Parliament, in its wisdom, in 1860, pronounced its standard of light to be the light of a candle, six candles to the pound, each burning 120 grains of sperm

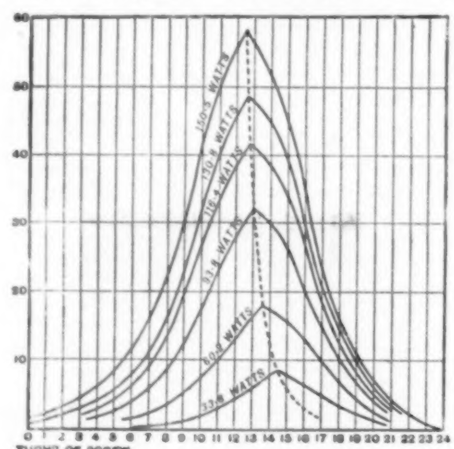


Fig. 1.

per hour, and this is at present the only legal standard known in England, though why, in the name of common sense, such a definition has been continued our legislators alone can guess, when it has been proved to be so faulty.

The standard of light for France is the Carcel lamp, which is equal to about 9·5 candles. Now, a light from a candle is a very pretty thing theoretically, but practically it is anything but practical, as it has the unhappy knack of burning inaccurately, particularly when one is anxious to shield it from draughts. Heat affects the rapidity of combustion, and if it be confined and no proper access of air be given it, its light may be most irregular. We have to remember that part of the energy of combustion is taken up by melting the sperm or wax, or whatever it may be, and if the surrounding air be heated the wax is at a temperature nearer its melting point than it should be when at a normal temperature. When the melting point is attained the liquid is decomposed and the flame results, and there is more liquid to be vaporized and vapor to be improperly consumed than in the normal state.

I show you a trace made by photography of the light from a candle burning under normal conditions. The light was admitted through a slit to sensitive paper, and a fresh portion of paper was continually being exposed. You will now see the irregularity of the burning. Of course, by taking several candles the variation is not so great, but even then you have to be sure that the proximity of the candles to one another does not alter the rate of burning.

An Argand burner, however small, will not, during a long series of experiments, differ 1 per cent. in light value. Here we have a proof of this. This small paraffin lamp was allowed to burn for three hours, and you will see that the band it makes is perfectly uniform in appearance, and when the measurement is made of the blackness produced by it on the photographic paper, it proves my statement is correct.

The apparatus by which these diagrams were made is a very simple one. It consists of a clockwork arrangement drawing a pulley, which pulley is in connection with a drum, which can rotate on its axis. Round this drum is placed sensitive paper, and a box, with a long slit in it, covers the drum. The light is placed opposite the slit, which is covered by a movable lath, in which is an aperture of a convenient width. As the drum moves, this aperture moves across the slit, and so we have a corkscrew band of exposure produced. With some clockwork the motion is regular in its irregularity, and every tooth of the train can be counted on it by noting the bands of varying exposure, and for this reason the clock was at one time abandoned, and the smooth motion of the sinking of the weight in subsiding water was substituted. This gave very good results, but for my purpose the clockwork was sufficient.

The sources of light I have mentioned are what may be called feeble sources of light, and cannot be used when a body is fairly absorptive, if the transmitted light is to be measured. We want in such a case a stronger source of light, and one which is practically constant. Such a source of light we have in the electric arc light. If we project upon the screen an image of the points where the positive pole is slightly behind the negative pole, with a fairly long arc, we become aware that there is a central part, which is higher than any other [shown]. It comes from a depression in the positive pole, and for the last eight years I have been in the habit of using this as a source of light of uniform intensity, and many hundreds of measures have proved it to be so. This, as several years ago I pointed out, was due to the fact that the temperature of this spot was that of the volatilization of carbon. It is an intense light, and may be taken as 50,000 A. L. per inch of surface, and very useful for a great many purposes, as we shall see as we proceed. Now we call all these lights which I have mentioned white, but it is quite evident that there is white and white if all these be white. I believe myself that Mr. Lovibond's definition of white is a good one, which is the light which is seen in a white fog about midday, and if we compare this light with any other we shall, I think, come back to it as being a very practical white light. Now the electric light is not far from this quality of light, and as such is very useful in comparing the transparency of objects by what is approximately daylight. We can measure the light of each part of the crater passing through a small hole.

We can at once see the difference between all the ordinary lights by a simple experiment. This box is divided into partitions with tissue in front, and in each partition we have a different source of light—a partial gas jet, an Argand gas burner, a candle and a paraffin lamp. It will be noticed that the light inclosed in a chimney is much whiter than those burned in free air, but you will also see that all these lights have various depths of yellowness when compared

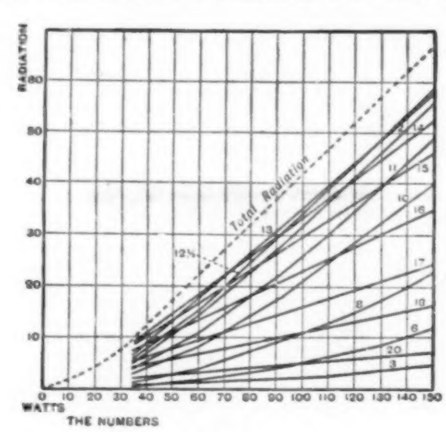


Fig. 2

with the electric light. It is quite evident that, even supposing they gave the same illumination, they are not all fit for standard lights. I take it that a standard light in photometry must always have the same quality of light as well as the same quantity of light. Now we can, by appropriate means, make the electric glow lamp light of the same visual intervals as a gas jet. The one before us is so, but it is evidently not of the same quality. One of the very best tests that we can make for ascertaining whether any difference in quality exists is to see if, when they are equally strong visually, they give the same photographic results. [An experiment was made with an electric light and an amyl acetate lamp, in which both were made of the same visual intensity, but photographically they differed materially.] You see that the amyl acetate lamp is decidedly the worse photographically.

Perhaps I can show you why this is. I take an incandescent lamp and cause it to glow: it goes red, to begin with; then I increase the current; it gets yellow, then whiter, and so on, till it is nearly white. I cannot make it as white as the arc light, for the reason that, as the temperature increases, the fusing point of carbon is reached, and that, as I pointed out, is the temperature of the crater of the arc light.

These temperatures, however, are subject to different amounts of energy expended upon them; and here I have a diagram showing how, with an increased energy expenditure on the same filament—that is, with an increased temperature—the different rays of the spectrum are altered in proportion. These diagrams are taken from measures made with a linear thermopile, moved through the spectrum. You will see that the higher the temperature, much more rapidly do the rays of high refrangibility increase.

The value of the abscissæ in Fig. 1 (in wave lengths) is as follows:

	λ		λ
1·25	5,900	13	14,650
5	7,250	17	20,750
9	9,900	21	27,500

These numbers apply to both diagrams, and in Fig. 2 the numbers attached to the different curves are those which are attached to the abscissæ in Fig 1.

Let me show an experiment. I will balance an electric light against the amyl acetate lamp, and expose a piece of paper to its action. I will increase the temperature and balance again, and expose another por

* Lectures delivered before the Society of Arts, London, 1894.—From the Journal.

tion of the same paper to its influence for the same time. Notice, please, the difference in the two. You will find that the highest temperature filament is much more "photographic." By this means all lights, which are due to the incandescence of solid particles of carbon, can be tested as to quality. Make them visually equal, and then see if they are photographically equal. For my own part, I believe that a knowledge of the photographic value of light is essential in the near future; for I cannot help thinking that there will have to be a registration of photometric values for record, independent of the eye, and this must be by photography.

For this purpose the photographic value and the visual value of every light used will have to be known and carefully recorded. We shall see soon how these records can be utilized, and become of permanent value in themselves, being capable of being measured at any date after being made, and remeasured if required. I throw on the screen the photographic values of a candle, an amyl acetate lamp, a gas jet, a paraffin lamp, and an arc light—all made of the same value as a candle visually [shown]. You will see that they vary enormously, and the scale of opacity below, which was made by exposing different parts of a plate to a steady light for different times, gives us a means of comparing one with the other.

I have said that all lights which are due to solid particles of incandescent carbon can be tested by means of photography, and I have shown you the deposits which certain lights cause on a photographic plate. There can now be but little doubt that a luminous candle flame is as much due to solid incandescent particles as the glow lamp we have been using. The final proof has been long in abeyance, but I think no doubt now can exist regarding it. First of all, if we examine the spectrum of the luminous part of the flame, we find that it is continuous, though occasionally a bright line of sodium in the orange puts in an appearance, but it is of no account. Now any light which emits a continuous spectrum must be due to a solid or liquid body in a state of incandescence, or to a gas in similar state, but under great pressure. The flame is certainly not liquid, nor is it gaseous under pressure. It seems, therefore, the light must be due to solids, and those solids must be so small that even a microscope of low power will fail to distinguish them. This fact (if it be a fact) enables us to put the matter to a good test. If we project a beam of light against a cloud of small particles, the rays which are most refracted (the violet and the blue) are violently scattered in all directions, as Lord Rayleigh has shown should be the case theoretically, and the greater the number, the more yellow is the light coming through them. There is one peculiarity, however, about these scattered rays, viz., that those which are scattered at right angles to the beam are what are termed polarized in one direction—that is, that if they pass through a Nicol's prism turned in one direction, they become quenched, while they will pass through readily if the Nicol be turned in the direction at right angles. You will see what I mean by the scattering by an experiment which I now make.

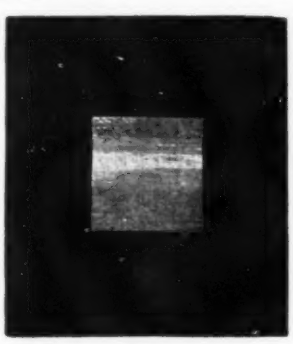


FIG. 3.

If to this clear solution of hyposulphite I add a few drops of hydrochloric acid, it becomes cloudy, owing to precipitation of fine particles of sulphur. I allow a beam of light to pass through the solution before I make the addition to the screen, and then add the HCl. The light becomes yellowish and then reddish, as the number of fine particles increase; that is, the more particles, the redder it becomes, and the more light is scattered, as a look at the cell testifies.

By precipitating mastic in water we get the same results. Here is some which has stood two years or more, and while it is turbid the beam of light passes freely through it, but scatters light on each side. Now, if I pass that broad beam of light first through a Nicol's prism, turned in one direction, and then through the solution, the path of the beam is clearly visible, but if I turned it in a direction at right angles, it is at once quenched. Its existence, in the first case, and its absence, in the second, shows that the light, coming at right angles to the beam, is polarized. This you can see for yourselves, at least most of you who sit in the proper direction; but for the sake of those who do not I take two photographs—one with the Nicol turned, so that the polarized light passed, and the other when it was turned, so as to present the beam. You see the result.

Now let us apply this to the small carbon particles. If a beam of intense light, such as that coming from a small image of the sun, be thrown on the flame of a candle, a white beam of sunlight should be seen on the flame, and a beam of white light passing through the flame. Unfortunately, I have not the sun at my command here to night, so I cannot show it, but you may take my word for it that such is so. Sir G. Stokes examined this white beam in a position at right angles to its direction, and found, by means of a Nicol's prism, that it was completely polarized; that is, that when the Nicol was turned in one direction, the streak of white light in the flame disappeared altogether. This establishes the fact that the luminous part of the flame is due to small particles, independently of any other proof. It appears to me, therefore, that one is correct in stating that the bright flames are due to measurement carbon. Into the theory of flames I will not further enter at the present time; this is enough for my purpose.

In case there be any doubt among you, I will show you some photographs of the phenomena I have taken.

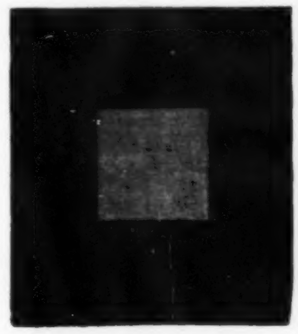


FIG. 4.

Fig. 5 is a photograph of an Argand gas flame, on which the rays of the sun, collected by a lens of about 8-inch focus, were concentrated, so as to pass along part of the circumference of the cylinder. The Nicol prism was turned in such a direction that the scattered rays would be unaffected in the left hand photograph, while it was turned at right angles to the first direction for the right hand photograph. In the left hand figure the track of the beam is readily seen, whereas any trace of it is absent in the right hand figure. Fig. 6 is the same, but the electric arc light was used in place of the sun. The results are the same.

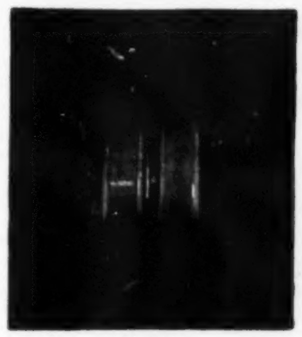


FIG. 5

FIG. 6.

Fig. 7 shows the results when the beam from the electric light is passed through a candle flame. In the one figure a broadish white band is seen, while in the other it is absent.

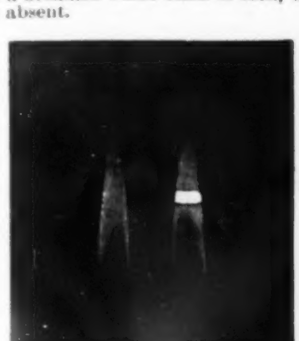


FIG. 7.

We are now in a position to see why it is some flames are whiter than others. When a chimney is used with gas, for instance, we find that the illumination is whiter—bluer, if you like the word better. The function of a chimney is to supply air to the flame, ample room being found through interstices to allow as much air as is needed to be drawn up into the chimney. In the case of hollow flames, such as an Argand burner, not only is the air admitted to the outside shell of the flame, but also to the inside. The consequence is that the small particles of carbon are heated to a higher temperature, as they are in the blacksmith's forge by the bellows, and they then emit a whiter heat before they are converted into carbonic acid. When one has a smoky lamp, there is one of two things happening—either the supply of air is insufficient to the chimney or else the flame is too high and the sudden access of cold air chills down the incandescent carbon particles till they become black, and smoke results. One of the most instructive experiments as to the need of air and warmed air to a flame is shown by lighting a paraffin lamp. It is an orange, smoky flame, but directly you place the chimney on it the light whitens and the smoke ceases.

I should here like to correct a very common notion which exists regarding the blackening of ceilings by gas flames. As a matter of fact, the carbon in a gas flame ordinarily is totally converted into carbonic acid. It is the ascending current of heated air that catches up the floating motes in the room and dashes them against the ceiling, to which some cling tenaciously, and gradually the blackening is encountered. A friend of mine lately put up the electric light in his house and placed the glow lamps close to his ceiling. He was astonished to find that the ceiling above them blackened to an extent which reminded him of gas. It was the current of warm air which caused the blackening. Similarly hot water pipes will do exactly the same thing. Heated air will ascend, and when it ascends it carries the motes and particles with them. In South Kensington Museum, ceilings which adjoin hot water pipes blacken quicker than where there is gas, the reason being that the volume of heated air is so large.

HOW A LENS DOES ITS WORK: A LESSON IN ELEMENTARY OPTICS.

By CLEMENT J. LEAPER.

A CERTAIN substance is believed by all scientific men to be present everywhere. We cannot see it, although we have reason to think that without it we could not see at all: we cannot weigh it, although we know we are right in saying that it cannot be without weight. This apparent paradox is the ether of the physicist.

Whether it really exists or is only a fiction time will tell, but we are at least certain that all phenomena in which light or heat play a part can be explained on the assumption that the ether is as real as water or as air. This ether can be set in motion in various ways, and when set vibrating at a certain rate our eyes interpret its motion as light, and the photographic plate changes the motion into a developable image.

Vibratory motion or vibration means motion taking the form of waves: motion in which the moving substance is not bodily transferred from one spot to another, but in which a wave travels instead of the body itself.

We have in the waves of the sea an example of motion of this kind; the wave advances and breaks on the sea shore, but the water itself merely moves up and down. Waves are conveniently represented in direction by straight lines, and these lines we call rays.

If we pierce a small hole in the shutter of a darkened room, taking care that the shutter faces the sun, we shall find that when a piece of paper is placed in a certain position opposite the hole, an image of the sun will be visible on it.

If we enlarge the hole, we shall find that the image becomes less and less distinct at the edges, although brighter all over, and that finally when the hole is made sufficiently large the image of the sun is replaced by an irregular patch of light.

What explanation can be given of all this? Light travels in straight lines from the sun to the sheet of paper, and to do so must obviously pass through the hole. (We speak of light passing through the hole when we really mean that a wave giving rise to light passes through.)

Let us in imagination divide the sun's circumference into four equal parts by means of two diameters bisecting each other at right angles, and let us call the extremities of these diameters A B C D. In order that the point, A, may form a distinct image on the sheet of paper, it will be necessary that the wave or simply the ray proceeding from A meet the paper at one spot only. If we cause to fall on the same spot the rays coming from B C D, we shall get an indistinct image, as each ray will form the image of the point on the sun's surface at which it originated. It is now easy to see why the size of the hole must influence the distinctness of the image.

If the hole is sufficiently small, the rays are prevented from overlapping, if not so small, the rays overlap to a certain extent, while if the hole is still further enlarged, we get not one, but a series of images, none of them distinct. If we confined ourselves to a hole of the size requisite to obtain a distinct image, we should find that the position of the screen would exert little or no influence upon the distinctness of that image, but would exert a good deal of influence upon its size.

The nearer the paper to the hole, the smaller would be the image, the further the paper, the larger the image.

What is true of the sun would also be true of any illuminated object placed opposite to the hole, a landscape for instance; and the experiment made in this way would reveal the fact that the image is invert, a proof that a wave produced in ether cannot bend round a corner. The darkened room with the hole in the shutter is really a very large camera, and a sensitive plate placed where the paper is supposed to be would under suitable conditions be impressed with a developable image. If we substitute for the darkened room an ordinary camera and for the hole in the shutter a piece of tinfoil pierced with a circular aperture supported in the position usually occupied by the lens, we have all that is needed for the production of so-called pinhole photographs.

It is sufficiently obvious that a small hole, indispensable if sharpness is wanted, means very little light, and in practical photography we want for many reasons all the light we can get.

The problem we have to solve in such a case is this: Given a hole an inch in diameter and a screen opposite to it, how are we to arrange matters so that a distinct image of whatever is opposite the hole may be formed on the screen? We do this of course by using a lens in the hole, when we find that a distinct image is formed on a screen placed at a certain distance from that lens. How does such a lens do its work? Evidently by compelling all the rays proceeding from any one point on the image to fall upon one and the same point on the

screen. A lens in its simplest state is a piece of glass so shaped that its surfaces form part of two spheres.

A ray of light passing from air to glass is bent, and the curves of a lens are so adjusted that all rays proceeding from any one point in front of, meet at a certain point behind it. An illuminated object is really an assemblage of an immense number of points of light. When a large hole is used their images overlap. A lens sorts these images and prevents them from overlapping.

If we draw on paper a line, A B, an inch long, and then draw diverging lines from each extremity of the line, we have got a rough representation of the waves emitted by a luminous line, A B. If we draw another line, C D, parallel to A B, so as to cut these radiating lines, we shall have a rough representation of a screen placed in front of the luminous line, A B.

In such a case no distinct image is possible, but a pinhole or a lens placed between A B and C D will obviously prevent the line from overlapping, and so secure a distinct image of that object to fall on a screen placed at a certain distance behind the lens. A moment's consideration will show the reason of this.

If the distance between a certain lens and the screen is in one case less than the distance between another lens and the screen in a second case, we shall find that with the first lens a smaller image will be obtained than with the second; the nearer the screen, the smaller the image, and vice versa. The degree to which a lens will bend a ray of light falling upon it depends upon the kind of glass used and upon its curvature. A short focus lens bends the rays very much, and forms a small image at a greater distance.

It will be observed in conclusion that although for convenience we have spoken of the lens as forming the image, what we really mean is that the lens so bends the rays as to prevent the already formed images from overlapping.

The image is really formed, not by the lens, but by the waves set up in the ether.—Photographic Answers.

IMPLANTATION OF DECALCIFIED TEETH.*

By Dr. OSCAR AMOEDO, Professor of the Ecole Odontotechnique, of Paris.

DENTAL implantation was introduced in oral surgery in 1886 by Dr. Younger, of San Francisco, Cal.

This operation consists in making an artificial alveolus in the alveolar ridge and fixing a tooth in it.

It is largely performed in America, and according to the reports presented last year to the International Dental Congress of Chicago, after eight years' experience, seventy-five per cent. of the implanted teeth continue to render very good service. Dental implantation is considered in the United States as a permanent operation, and Dr. Ottofy, in his report addressed to the same congress, made the following statements:

1. Implantation has been practiced for a sufficiently long period to entitle it to be accepted as a legitimate operation in oral surgery, which the dental surgeon should have the privilege to perform, assuming the attendant risks as he is doing in other operations. This statement is made as the result of observations extending over a period of nearly eight years.

2. That in view of the fact that all dental operations are more or less of a transitory character, implantation deserves to be classed as a permanent operation in the same sense in which other operations performed by dentists are considered permanent, and it should not be considered merely a fanciful experiment.

3. That no operation of the dentist so nearly reproduces nature as that of an implanted tooth, and, when successful, the result in appearance and comfort cannot be excelled by any other operation within the domain of the entire science of dentistry.

4. That the operation should not be performed in any cases except those which have been as carefully selected as they would be and as they are for other operations.

The success of this operation is due principally to two great discoveries—local anesthesia by cocain and antisepsis.

Thus one injection of cocain produces such complete anesthesia that the bone can be trepanned without inflicting any suffering on the patient.

Antisepsis makes the operation devoid of all danger. All infectious inflammation and the contagion of tuberculosis and syphilis are also avoided. The only complication that can result is absorption of the root and the subsequent loss of the implanted tooth, an identical phenomenon to that which happens to milk teeth.

This accident occurs generally when the root has not been sufficiently fixed, on account of the occlusion with the antagonizing teeth; especially is this so with the cuspids. To avoid this, I always make use of very solid platinum wire ligatures for the bicuspids; for the incisors and the cuspids I employ a little apparatus invented by myself.

This apparatus (see Fig. 1) consists of a plate of pure

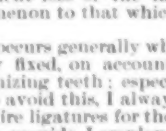


FIG. 1.

checked silver (Michael system), adapted with a burnisher to the back of the three incisors when there is only one implantation. Six platinum wires are soldered to the plate. Of these, two single ones are attached to the end of it, and two double ones in the place corresponding to the junction of the implanted tooth and the two neighboring ones.

After having filed and adjusted the apparatus, it should be attached to the back of the teeth with cement. The platinum wires are then passed between and twisted round the front near the necks of the teeth. This apparatus, thus constructed and applied, makes of the three teeth a solid block, and immobilizes them.

Fig. 2 represents the apparatus seen from the back of the incisors, and Fig. 3 from the front.

* Read before the Eleventh International Medical Congress, Rome, 1894.—Dental Cosmos.

I was lucky enough, during my investigations, to discover in the laboratory of Dr. Poirier, of the Paris faculty, an inferior maxilla with a second milk molar ankylosed between the first permanent molar and the first bicuspid. A part of the root of this milk tooth was reabsorbed. On account of its fixity, a process of calcification resulted, which had the effect of finally

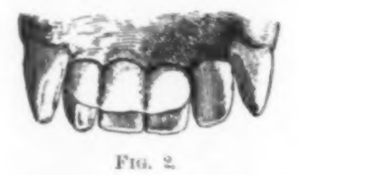


FIG. 2.

soldering the tooth to the maxilla, causing the pulp to disappear. This was replaced by an osseous tissue.

To explain the consolidation of the implanted, reimplanted, or transplanted tooth (in the three cases

FIG. 3

the work of consolidation is the same), three theories have been advanced:

1. Revivification of the pericementum of the tooth and adhesion to the alveolar wall.

2. Encysting of the root in the alveolus.

3. Intimate soldering of the root to the bone.

In the first case, the tooth retains its pericementum. Once introduced in a natural or artificial alveolus, it is asserted that the pericementum is revived, even a long time after it has been out of the mouth. Vital relations are established directly with the bone (in case the alveolus is artificial), or with the alveolar periosteum (if the alveolus is natural). In this case all returns to its normal state.

In the second case, the tooth is said to become encysted, as a lead bullet is in the bones; or more properly said, the pericementum does not play any part, and the tooth is only kept in its place by the intimate compression of the alveolar walls, without any soldering of the surfaces.

In the third case, the pericementum becomes useless, and a real adhesion takes place between the root and the alveolar wall.

I consider the theory of reviving the periosteum entirely wrong; the roots implanted or reimplanted are deprived of all movement and produce, on percussion, a clearer sound than the neighboring teeth. It is impossible, therefore, to admit the existence of a periosteal membrane between the root and the alveolus.

The theory of the tooth becoming encysted is also not acceptable. Histological examinations have demonstrated that the osteoblasts, which originate from the receiving bone, penetrate sometimes even to the cavity of the pulp.

The only explanation left, therefore, is the fusion of the root and the osseous wall by a chemico-vital process. In fact, according to my view, this is what takes place: the implanted tooth, acting as a foreign body, irritates the bone and produces an osteitis with formation of lymph cells, which are arranged in line and form an embryonal membrane throughout the periphery of the alveolus. These embryonal cells advance toward the root until they cover it. The decalcification and the erosion of the root begin, and afterward can be seen how the osteoclastic cells, giant cells with acid reaction (lacteous acid), which form little bays on the surface of the root, have been formed. If, then, the tooth is sufficiently firm and the general condition of the patient is good, the root does not act any longer as a foreign body, and the resorption stops.

The embryonal tissue formed between the tooth and the alveolus is soon vascularized; by degrees calcareous deposits are also formed, and the progress of the osseous transformation can be followed, until finally the root and the alveolar wall are, as it were, soldered together.

The clinical proof of what I have indicated is the clear sound produced on percussion of the implanted teeth, and the resistance to extraction. This resistance is sometimes so great that after an implanted tooth becomes consolidated it is impossible to extract it without breaking it.

For the purpose of facilitating this chemico-vital process caused by the uniting of the tooth, I decalcify with chlorhydric acid the coat of cement one-half a millimeter in depth before implanting the root. The process for decalcifying is the following: boil the tooth in mercury bichloride, then dip during three or four hours in a solution of chlorhydric acid of ten per cent., and probe it from time to time with a sterilized knife to judge the thickness of the decalcification. As soon as the knife penetrates half of a millimeter, wash the roots and neutralize them with ammonia.

It is evident that when the root has its crown, this must be isolated from the acid with a piece of rubber dam or a rubber tube.

The decalcified teeth can be preserved in a solution of phenosalyl of one per cent. To make use of them, the cavity must be enlarged at the apex and filled with salol liquid iodoformized. This substance has sufficient resistance to remain in the canal, and is soft enough to be absorbed in case of reabsorption of the root.

The clinical results that I have obtained with such decalcified teeth have confirmed all that I had foreseen. These teeth are more easily implanted and are more quickly and more uniformly consolidated than the dry teeth without pericementum, or even the fresh ones that have it.

But the most important point is the absolute innocuity of this method. All danger of contagion from syphilis, tuberculosis, and other affections is avoided, because these teeth are rendered aseptic, and can be kept in that state.

A stock of previously decalcified roots should be kept in readiness, and when they are wanted a crown in porcelain should be fixed to the root. These crowns please the client, and can be ground so as to articulate with the antagonizing teeth, losing very little of their solidity.

It has sometimes been observed, when a disk of the gum has been lifted with a circular bistoury, that the substance around the tooth implanted has diminished in size; to avoid this I make my incisions as shown in Figs. 4 and 5, and then implant the tooth. The gum

FIG. 4.

FIG. 5.

falls below the normal level, but during the cicatrization it comes back to its natural state and at the same level of the neighboring teeth.

I began my experiences in 1888, and I have just received a letter from one of my first clients for whom I implanted a molar. He tells me that his tooth is still very solid and gives him entire satisfaction.

I have made one hundred and fourteen implantations. Whenever local infection has occurred I have removed the tooth immediately, and washed the alveolus with bichloride, painted the cavity with iodine, and replanted the tooth. Whenever the consolidation has failed, this depended on the want of immobilization of the tooth.

My plan of procedure for implantation is the following:

1. Disinfection of the mouth with a solution of mercury bichloride of 1 : 4000, or phenosalyl one per cent., or permanganate of potassium 1 : 2000, injected with a syringe of my own invention (Fig. 6).

FIG. 6.

2. Injection of one centigramme of phenyl-cocaine (Poinsot) direct to the bone with a sterilized syringe.

3. Deep incision of the gum in the shape of an H (Figs. 4 and 5). The gum should be rapidly dissected, carrying the periosteum with two right and left instruments that I have had made for me (Fig. 7).

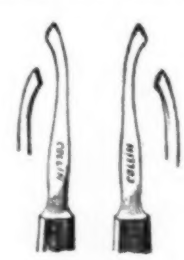


FIG. 7.

4. Trepanation of the bone with trephines mounted in the dental engine.

5. Implantation of the tooth introduced by a strong friction with the automatic mallet, at the extremity of which a piece of wood is attached.

6. Immobilization of the tooth implanted by ligatures or by a special apparatus.

CONCLUSIONS.

I. Implantation was introduced in oral surgery by Dr. Younger, of California.

II. It can be performed without pain by the use of cocaine.

III. With antisepsis, the inflammations, the infections, and the contagions can be avoided.

IV. The pericementum disappears completely once the tooth has consolidated. The adhesion produced between the root and the alveolar wall is by chemico-vital process.

V. Decalcified teeth facilitate this work, and are more easily made and kept sterile.

TREATMENT OF DOMESTIC ANIMALS POISONED BY EATING WILD PLANTS.

As a rule animals have an instinctive repugnance to eat of any plant or vegetable which is injurious to their well-being. But accidents of this character occur not infrequently at this time of the year. The farmer in the majority of cases takes no steps to eradicate harmful plants from his fields and hedgerows. Aconite, digitalis, savin, hemlock, hellebore, etc., affect animals much in the same way as they affect man.

The symptoms usually presented in cases of poisoning of animals through eating injurious plants may be either an irritative state of the digestive organs, as is generally shown when animals have eaten of such acrid plants as are found in the Ranunculus order; a constipated and comatose condition as the result of such poison as large quantities of oak shoots, acorns, etc.; or there may be evidence of brain and spinal affection as the result of absorption of nerve poisons, and shown either as a delirious excited condition or may be a paralytic state.

In the absence of absolute knowledge of the cause of the disease, treatment should be directed to combat and alleviate the condition shown from a purely common sense point of view; and as it is not possible in our larger domestic animals to evacuate the contents of the stomach by emetics, it follows that efforts to get rid of the offending material must be by means of medicines. In the case of an irritant of the alimentary canal having been absorbed, increased action of the bowels occurs, amounting in many cases to diarrhœa or even dysentery, with often a filthy condition of the fæces, irritation of the bladder, and frequently a frothy, filthy discharge from the mouth and nostrils. The irritated organs must in such cases be soothed by demulcent non-irritating medicines, chief of which would be the administration of such as linseed or castor oil, either of which may be given to the horse or cow in doses of 5 to 10 oz. every three or four hours, and to pigs, sheep, etc., in proportionately smaller doses, following this up by the exhibition of demulcent drinks, as oatmeal gruel, starch, milk, etc., but withholding all solid food until the urgent symptoms have passed off, and then along with carefully selected food we may give stimulants, such as the alcoholic or ammoniacal, or, better, both combined; perhaps the best of which would be the spt. am. aromat. or a cheap substitute in doses of from 4 to 6 oz., well diluted, for the larger animals and 1 to 2 oz. for the smaller.

In cases of the second class, where the symptoms point to a constipated and probably lethargic condition, the plants causing which will be familiar to most chemists, it is essential to get rid of the offending material as quickly as possible, for which purpose a purgative should be administered—the best to horses being aloes in solution, in doses of 8 to 12 dr., and to the cow either Epsom or Glauber salts, followed in both cases, if the bowels do not respond in from eighteen to twenty-four hours, by repeated doses of linseed oil, in quantities of 8 to 16 oz.; and here, again, stimulants, as before, will be absolutely necessary.

In the third class, where obviously the brain or spinal cord is affected, the plants causing which may be defined as nerve poisons, no general rule can be laid down, but the treatment must in all cases follow the individual symptoms. If the poison is a nerve stimulant, such as nux vomica or allied plants, nerve sedatives are required. If a depressant, as hyoscyamus or ergot, stimulants and nerve tonics are indicated. It may be taken as a rule that, where the dose is not known of any medicament, if we multiply the full human dose ten to fifteen times, we can arrive at a fair dose for the larger animals, and three to four times for the smaller ones; and in every case a dose of physic (laxative) will be useful.

It should be noted that, if nerve stimulants are required, nux vomica should never be prescribed in any form for the dog, its action in these animals being so uncertain as to constitute a positive danger even in infinitesimal doses.

LECTURE APPARATUS FOR THE STUDY OF CONDUCTIVITY.

THE teaching of physics, in order to be practical and fruitful, requires before all things else, the use of simple and inexpensive apparatus, without which the professor is obliged to confine himself to theoretical instruction. In this order of ideas, we make known the apparatus for the study of conductivity devised by Mr. Armand Leyritz, preparator of physical and natural sciences at the Arago School, and which the committee on scientific material for lyceums and colleges has recently adopted.

The inventor has especially endeavored to facilitate the demonstration of the professor by removing doubt from the minds of his pupils as to the results of experiments that they do not habitually see or that they see to a disadvantage.

As we know, in order to demonstrate the conductivity of bodies for heat, the classical apparatus of Ingenhouz is employed in lecture courses. With this apparatus students have never been able to witness the fusion of wax upon the rods of different solids, and the curve of conductivity has been seen with difficulty, even by the professor. Mr. Leyritz replaces the rectangular box of Ingenhouz by a brass cylinder (Fig. 1) carrying at its upper part a funnel through which the boiling water is introduced. This funnel is closed by means of a stopper that permits of closing the cylinder hermetically and of thus preventing any loss of heat. The rods of the different solids, 16 centimeters in length, instead of being fastened by unequal thicknesses of solder to one of the faces, enter the cylinder to the extent of half their length, by means of small brass sheaths, as far as to the opposite side. Each of these rods carries six equidistant grooves or channels designed to receive, upon their point, small ovoid masses of very fusible modeling wax, made by means of a special mould in the form of pincers. These masses are all of the same form, weight and bulk. The cylinder being full of boiling water and closed, we see the masses of wax bend over in succession, in following the grooves upon which they are placed, and then fall, in measure as the heat is propagated in the rods. There comes a moment in which we can very well ascertain the curve of conductivity by means of the masses that remain upright, and which we find, in a manner, materially traced.

In order to show the disengagement of heat produced by chemical combinations, Mr. Leyritz has devised an arrangement that permits of performing the experiment in a simple and striking manner. The apparatus (Fig. 2) consists of a glass vessel whose cover is provided with an aperture through which the liquid

FIG. 1.—APPARATUS FOR STUDYING THE CONDUCTIVITY OF SOLIDS.

inside can be agitated so as to effect a perfect mixing of it. This cover allows of the passage, with hard friction, of a funnel tube, of a small test tube drawn out at its upper extremity, and of an alcohol thermometer 0·5 meter in length, which is so arranged that the column of liquid and the graduation are visible to the entire class without its sensitiveness being interfered with.

The receptacle is half filled with water, and then, after a little sulphuric ether has been introduced into the test tube, in operating as in the filling of a thermometer, sulphuric acid is poured in through the funnel tube, with the usual precautions. The tempera-

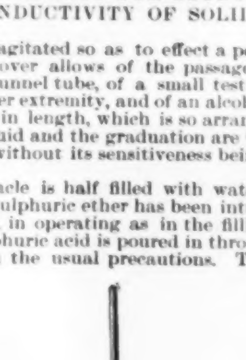


FIG. 2.—APPARATUS FOR DEMONSTRATING THE DISENGAGEMENT OF HEAT PRODUCED BY CHEMICAL COMBINATIONS.

ture immediately rises—a fact that is shown by the thermometer. Toward 35° the ether boils in the vessel and the vapors of it can be lighted at the pointed extremity of the tube.

Another apparatus (Fig. 3) is designed to show the conductivity of gases for heat. An inverted test glass, whose base is mounted in a brass sheath provided with apertures, is traversed at its upper part by a fine platinum wire extending to a certain distance on each side. The free extremities of this wire are held by clamps carried by two metallic pillars, into which is passed an electric current, such that the wire reddens completely in

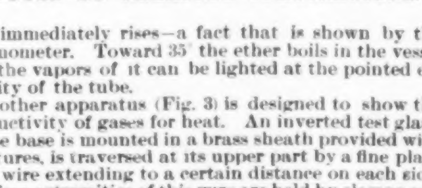


FIG. 3.—APPARATUS FOR DEMONSTRATING THE CONDUCTIVITY OF GASES FOR HEAT.

the air. By means of a tube bent at right angles, a current of carbonic acid is made to reach the top of the test glass.

The wire continues to redden throughout its entire length.

Finally, the test glass is filled with hydrogen (an operation that is attended with no danger), and the interior portion of the wire is extinguished. The experiment is performed in an elegant, very visible and very demonstrative manner.—*Le Genie Civil.*

BIRD'S EYE MAPLE.*

By W. J. BEAL, Agricultural College, Michigan.

THE wood of some trees of sugar maple, on removing the bark, is found to be irregularly covered with conical pits, which are more or less rounded at the bottom. In many instances these pits are irregular in outline; some are longest up and down the tree, and not infrequently two or more are partially united. The pits generally, though not always, have a depth equal to the greatest diameter. The largest pits are about a quarter of an inch in diameter, and vary in size to the smallest, which can barely be seen with the unaided eye. If the wood be split parallel with the bark, the side of the stick so removed toward the heart of the log will contain more or less conical projections, such as come from the pits left in the counterpart of the block.

On removing the bark, numerous small cones are displayed on it, such as descended and just filled the pits in the outer wood. By examining many radial sections, one will frequently find instances where the "bird's eye" is just beginning, usually very small. From this beginning the pits usually grow larger and broader as we successively come to the older wood.

Sometimes a pit runs of even size for many years; sometimes it abruptly disappears as we view the wood from that which is younger to that which is older, and sometimes it becomes so broad that for an inch or more it will be filled with bark. There may be some interruptions where the bark disappears to reappear after a few years. I have not been able to find any trees showing "bird's eye" until they had acquired a diameter of about three inches or more, and then the marks were very small. Such young trees have all been rather crooked and knotty, with irregular swellings on the trunk, compressed in some places. A smooth, straight, thrifty, healthy looking maple seldom shows the "bird's eye" to any extent. The "bird's eye" marks may be abundant and well marked on one side, or, perhaps, half or two-thirds of the circumference of the tree, and not be present on the rest of the tree. They may be well shown all around the lower part of a tree and partially disappear after a few feet above. "Bird's eye" is rarely found on the limbs of a tree, and seldom shown on the trunk above the lower limbs.

Mixed with the "bird's eye," or more or less independent of it, will often be found "blisters" and wanes and curls of all conceivable shapes. When such wood is split open, parallel with the bark, it often presents the appearance of folds of rich satin.

Where "bird's eye" maple is cut for market, most of the maple trees of the forest show somewhere the peculiarity to a greater or less extent, but, to be very valuable, this peculiarity should be abundant and extend clear around the trunk, and should extend far enough up the trunk to furnish logs of sufficient length to pay for marketing. These logs should be destitute, or nearly so, of deep pits containing bark or black streaks or shakes, and the thicker the sap wood the better, as the dark colored or heart wood is not salable.

At Vanderbilt, in Otsego County, Michigan, Mr. John Berry says the best trees are found on the richest land with clay subsoil, where, perhaps, one tree in twenty-five is marketable, while on thinner soil the trees are not so nice and the proportion of marketable trees may be one in forty.

They are shipped to Grand Rapids, New York, or to England, or to some other place, where they are cut into veneers.

No one can for certain pick out a good tree without peeling or cutting off pieces of bark here and there in several places on the tree. They often cut a pole to lean against the trunk to enable them to make examinations at a height of ten or fifteen feet. Many of the logs are finally cut in lengths of two to eight feet, thoroughly steamed, placed in a secure position to be turned over and over against a long knife, which cuts the veneer, which is the sixteenth of an inch or more in thickness. This is dried and glued onto boards or other cheap veneer and polished.

I have found several other species of trees showing the "bird's eye" to a greater or less extent, usually only affecting the tree in a slight degree, not sufficiently to be used as veneer. Notably among these is the wood of the beech and more rarely the wood of the hickory, white ash, black cherry, American elm, Norway pine, red maple and probably many other species. In some cases which I have seen the depressions, instead of being circular, are narrow and lengthened, sometimes half an inch or more. In some specimens of sugar maple and beech these long, narrow depressions run up and down the tree; while in some observed in sugar maple they extend transversely around the tree across the grain.

Occasionally the wood of sugar maple, beech, white ash, and sometimes other species is regularly curly, with the hollows and crests of the wanes well seen by splitting the stick in radial section. These wanes vary in length from three-eighths of an inch to a foot or more from the crest of one wane to the crest of another. In white ash and sugar maple and beech and rarely in black walnut and other species the wanes occur irregularly on the wood, parallel with the bark. Such wood is often used as a veneer, and in case of white ash it is spoken of as "calico ash."

Instead of small pits in the wood, as seen after removing the bark of "bird's eye" maple, the wood of several kinds of trees occasionally contains more or less protuberances or cones, while in the bark there is a corresponding pit. These have been seen on the red maple, sugar maple, hickory, and American elm. In some cases they appear to have come from adventitious buds.

What causes "bird's eye" in maple, beech or other wood?

The Indians of Northern Michigan have always attributed it to damage done the trees by the pecking of birds. I can find nothing in fact to warrant such an opinion. Occasionally maples are pecked by wood-

* Read before the American Association, Toronto, 1889.

peckers, but such places do not become pits in the wood, as is the case with "bird's eye."

In case of the beech, larvæ of insects are sometimes found in the inner bark extending to the cambium, which they injure more or less. Sometimes the insect kills a small spot of the cambium, and a black spot on the wood and bark is the consequence. This spot is sometimes enlarged in succeeding years by the action of more insects and probably by the presence of fungi. In some instances the insect seems to merely check the growth of the cambium in the spot where it grows, and a pit appears in the wood at this place. In other cases "bird's eye" beech seems to start without the aid of any insect.

I have found no insects in the bark of the sugar maple which cause the "bird's eye," yet when fresh living specimens are examined in the summer, the cambium at the bottom of the pits appears to be more or less injured, showing minute spots of a yellowish brown color, possibly started by some kind of bacteria.

WHAT IS A STAR CLUSTER?*

By A. C. Ranyard.

According to the generally received nebular hypothesis, our sun and the luminous stars have been formed by the condensation of nebulous masses. Kant, Sir William Herschel, La Place, and the other earlier exponents of the nebular hypothesis who lived before the great principle of the conservation of energy had been propounded, assumed that the nebular masses must, when originally distributed in space, have been intensely heated to a far higher temperature than the luminous stars which were evolved from them.

The great difficulty of conceiving of a hot nucleus remaining after ages of radiation into space from the vast surface of a nebular mass does not seem to have occurred to these earlier theorists, or, if it occurred to them, the difficulty was swept on one side by assuming a still higher temperature for the parent nebulous mass. But when the mechanical equivalence of heat with other forms of energy was demonstrated, it became evident that the heat of the condensed nucleus might be derived from the motion of the nebulous particles colliding with one another during condensation. Thus a method of accounting for the great heat and light of the stars was offered, and the popularity of the nebular hypothesis was greatly enhanced.

It seemed reasonable to suppose that we should find large and small nebulous masses in all stages of condensation. The large and irregular nebulæ were pointed to as nebulous masses which were in the earliest stages of condensation. Nebulous stars were supposed to be in an intermediate stage, and ordinary stars were in a still later stage, approaching a condition in which they would cease to shine as incandescent bodies. But if the ordinary assumptions of the nebular hypothesis were true, the earlier stages of condensation would occupy a much longer period than the final stages, and we might expect to find a much greater number of oblate nebulous spheroids (such as the hypothesis of La Place assumes) than of stars in the later stages of condensation before their incandescent condition had passed away. It could hardly be urged that the stars and nebulous condensing masses were all so far removed from us that they all equally appeared as stellar points of light; for incandescent spherical masses, comparable in diameter with the orbit of Neptune, or even with the orbits of Saturn or Jupiter, would in our larger telescopes present very recognizable disks if they were situated at distances from us ten or fifteen times as great as the space which separates us from our nearest stellar neighbors.

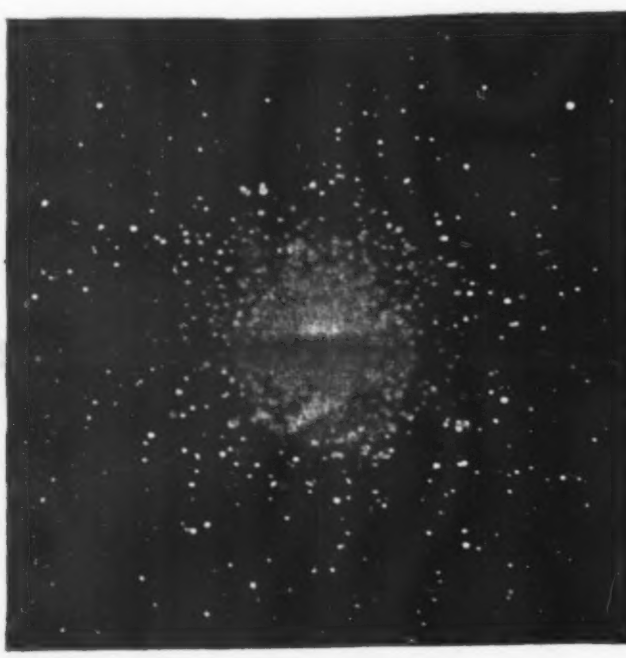
While there are millions on millions of stellar points of light to be observed in the heavens, the number of spherical nebulous masses revealed by the telescope is comparatively few, a fact which may be reconciled with the nebular hypothesis by assuming that the condensing masses only commence to be incandescent when they have shrunk to diameters of a few million miles, and that in the earlier stages of incandescence the nebulous matter is cold and dark, or only glows at a faint red heat, which is not sufficiently bright to render the nebulous mass visible at a distance.

There are also a few nebulous rings and spirals which shine with a faint nebulosity in the heavens, and a great many nebulæ of very irregular form generally surrounding stars or associated with groups of stars, in a manner which would seem to indicate that the nebulous matter had issued from the stars rather than that it is condensing about them, for frequently there are arms of nebulosity or nebulous structures which appear to spring from the place occupied by a star or group of stars within the nebula. Such nebulæ would seem to present a closer analogy with the solar corona than with the fiery condensing mists conceived of by La Place.

The form of the coronal structures about our sun indicates that the coronal matter has issued from the sun, and though we may, no doubt, assume that the matter which is shot forth from the sun, as a general rule, returns to it again, the brighter structures of the corona seem to indicate by their form that they are composed of matter on its outward course, that is, in its hot condition, as it is shot upward from the sun. There are no coronal structures the form of which indicates a downward flow of matter, and it seems, therefore, reasonable to assume either that the coronal matter returns to the sun as a uniform mist or that it returns in a comparatively non-luminous form.

There seems to be a very close analogy between the irregular nebulæ and star clusters. Recent photographs indicate that most star clusters are nebulous, or contain wisps of faint nebulosity, and the irregular nebulæ are all associated with groups or clusters of stars. Irregular nebulæ, as well as star clusters, are distributed along the region of the Milky Way, and seem in some way to be associated with it, while the smaller and regular nebulæ have a tendency to cluster in the poles of the Milky Way.

If the nebulous matter of the large and irregular nebulæ has been shot forth from stars, it seems to follow that the nebulous matter of star clusters has had its origin in the stars of the cluster, rather than that the stars of the cluster have condensed from the nebulous matter.



UNTOUCHED ETCHED BLOCK MADE FROM A PHOTOGRAPH OF THE HERCULES CLUSTER TAKEN BY MR. W. E. WILSON ON AUGUST 5, 1894.

Prof. George Darwin pointed out some four or five years ago that if two solid bodies were to collide with planetary velocities, such a rapid evolution of gas would take place, by reason of the heat developed at the region of contact, that the bodies would rebound from one another almost as if they were perfectly elastic bodies. If the moving bodies were liquid or gaseous, no doubt a similar evolution of heat at the region of contact would take place, causing an elastic rebound, and it seems not improbable that within a short period after such a collision the gaseous matter evolved at the region of contact would be distributed in space between the rebounding bodies, forming as it were a nebulous ligature between them; but it seems difficult to account on this theory for a line of stars joined by nebulosity such as we find in the Pleiades, or for a series of stars in a curving line ligatured together by a band of nebulosity.

The very beautiful picture of the Hercules cluster which illustrates this paper has been reproduced from a photograph given me by Mr. W. E. Wilson, of Daromona.

The light-grasping power of Mr. Wilson's instrument is so great that, with only an hour's exposure, smaller stars and a considerably larger area of nebulosity have left their imprint upon the photographic plate than are to be traced upon the photographs made at the Lick and Paris observatories with exposures three times as long.

One of the most interesting features in Mr. Wilson's photographs is that many of the stars in the outer parts of the cluster are distinctly seen upon the photographs to be united by ligatures of nebulosity. It has been very difficult to reproduce these nebulous ligatures in the etched blocks or in the collotype plate. They are, perhaps, most marked and easily recognizable in the upper right hand quadrant. But there is no doubt about their existence, and in the silver prints and platinotype prints made from Mr. Wilson's original enlargements they are very clearly shown. Mr. Wilson himself has no doubt as to their actual existence; that is, he believes that they are not due to any optical or photographic defect.

It will be remembered that in the enlargements from the Henry photographs similar nebulous ligatures between stars were observable, joining them up into branching streams radiating outward from the central regions of the cluster. We therefore appear to have corroborative evidence in these photographs by Mr. Wilson, proving that in both the inner and outer parts of the cluster the stars are physically connected with one another in streams which seem to be radially arranged with respect to the center of the cluster, and that these streams of stars linked together by nebulosity are intimately associated with streams or patches of the light-absorbing material which gives rise to the dark lanes or patches.

* Abstracts from an article in Knowledge.

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